Volume VI
of
Final Report Under Contract NAS 8-11523

Zero Leakage Design For Ducts And Tube Connections For Deep Space Travel

X-CONNECTOR FEASIBILITY STUDIES

by

J. A. Bain

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ZERO LEAKAGE DESIGN FOR DUCTS AND TUBE CONNECTIONS
FOR DEEP SPACE TRAVEL

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of
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September 1967

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PROPULSION AND VEHICLE ENGINEERING DIVISION
GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
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FOREWORD

This is Volume VI of a six-volume final report covering work performed between 5 July 1963 and 30 June 1967.

As a result of previous work on this contract, the General Electric Company was in a position to assist the National Aeronautics and Space Administration in the selection of promising new connector designs which should be subject to feasibility investigations. The X-connector, proposed by Parker Aircraft Company of Los Angeles, California, appeared to merit a major feasibility investigation. That investigation was pursued and is here documented.

Development work, including design, manufacture, and tests proceeded at the Parker Aircraft Company, in Los Angeles, under the direction of their program manager, D. T. Johnstone. The work was critiqued and guided by the General Electric Company's Research and Development Center, in Schenectady, New York, where extensive tests under simulated environments were also conducted. The project engineer for the General Electric Company was first L.G. Gitzendanner, then F.O. Rathbun, and finally J.A. Bain. Overall technical direction was provided by H.W. Fuhrmann of NASA's George C. Marshall Space Flight Center.

The six volumes contained in this final report are:

Volume I -- "Fundamental Investigations"

Volume II -- "Connector Concept Studies"

Volume III -- "Guide in Selecting Duct, Tubing, and Gasketing Materials for Space Vehicles and Missiles"

Volume IV -- "New Connector Designs and Testing"

Volume V -- "Tube Connector Design Principles and Evaluation"

Volume VI -- "X-Connector Feasibility Studies"

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Section 1

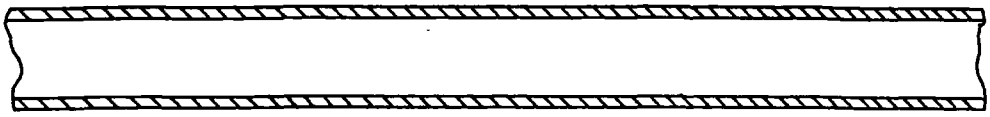
INTRODUCTION

Modern studies of fluid connectors usually have weight reduction and increased reliability as their primary objective. A discussion of these aims and the reasons for them has been written by P. G. Haas (Ref. 1). When an attempt is made to meet these objectives in a practical connector design, some very important restraints must be observed. For example, the connector must be suitable for use with standard sizes of tubing, and a minimum number of parts must vary as the wall thickness of the tubing varies. K. Bragg (Ref. 2) gives a comprehensive discussion of these restraints as well as weight reduction and increased reliability. The X-connector development was initiated because it showed promise of reduced weight and increased reliability in a design that would satisfy practical restraints. It was deemed appropriate to accept a semipermanent connector to achieve these goals.

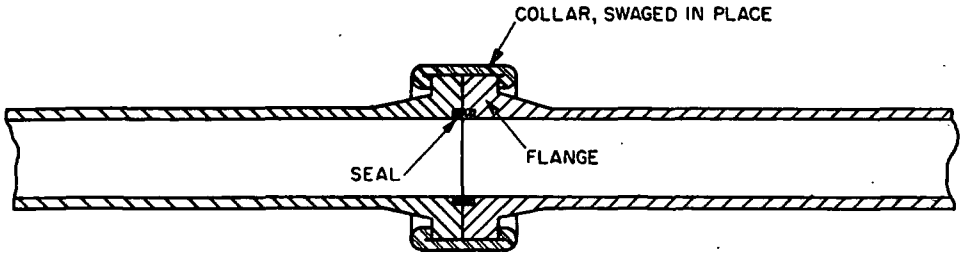
Consider the problem of weight reduction and the comparative advantages of different kinds of connectors. It seems invariably true that the weight of a fluid connector increases as the convenience of separation increases. Figure 1 shows this by contrasting a solid tube, an X-connector, a flanged connector, and a threaded connector. The method of joining the tube to the flange is omitted in all cases and the X-connector seal is not shown, except as a schematic representation. The figure is only an aid for comparing different ways of joining two flanges together. Notice that the increase in weight from a to d is accompanied by increasing convenience of separability from a to d.* Indeed, the weight is added for the mechanical convenience of separability by providing wrench flats and the like, required of separation tools.

To substantiate this consider the flanged connector as compared to the X-connector. The collar serves the same purpose in the X-connector as the bolts in the flanged connector. They are both tension members, which serve to pull the flanges together and hold them against the seal. In using a flanged connector, however, it is necessary to provide clearance for the bolts. This clearance is required in the radial direction so that the wrenches will clear the tubing; it is also required in the peripheral direction so that the wrenches will clear the adjacent nuts and bolts. Thus a designer must make large flanges to provide mechanical clearance. In moving the bolts out to this large diameter, the designer has loaded the flanges of the connector with a larger bending moment than is present in the X-connector. He has also placed the bolts in a position of poor mechanical advantage for providing the sealing force. When

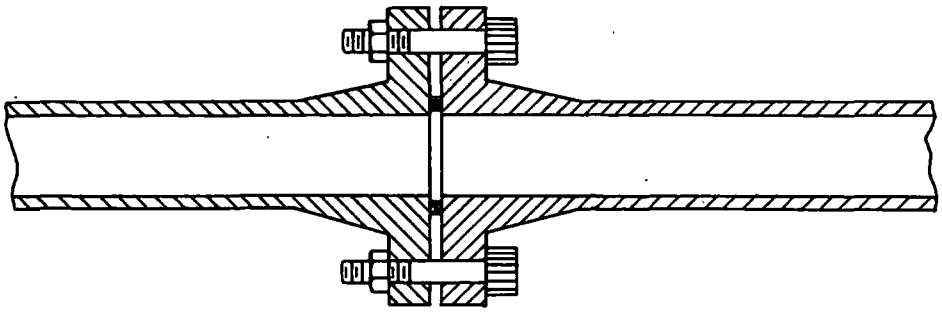
*It may not be commonly realized but a flanged connector is in general more efficient than a threaded connector with regard to weight. This is probably not apparent because threaded connectors are usually used with small tubes, and flanged connectors with large, heavy ducts. However, if one were to construct flanged and threaded connectors for the same size tubings, the flanged connector would probably be lighter than the threaded one. This is substantiated by studies (Ref. 3) performed under Contract NAS 8-4012.



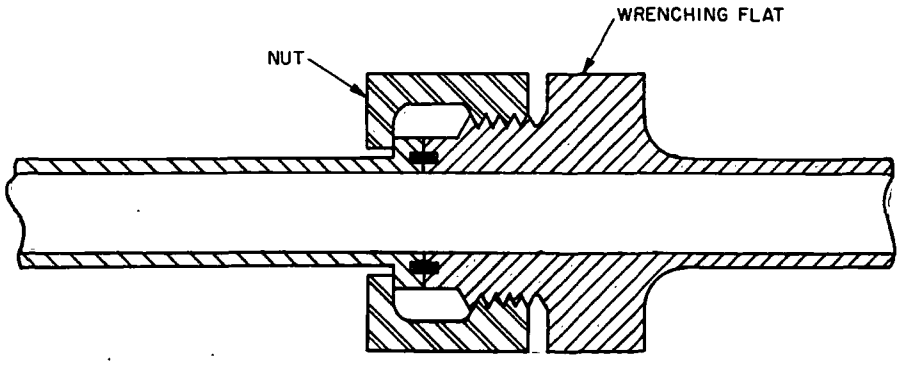
(A) PLAIN TUBING



(B) X-CONNECTOR FLANGES AND TUBING (SLEEVES NOT SHOWN. GASKET SEAL SHOWN FOR COMPARISON, BUT NOT USED)



(C) TYPICAL FLANGED CONNECTOR



(D) THREADED CONNECTOR

Figure 1. Connector Comparisons

the designer considers the results of these steps, he sees immediately that he must make a thicker flange and he must provide more bolt load in order to maintain a seal. This iteration continues until the designer is satisfied with the structure of the connector, and by the time he has finished, the flanged connector will be considerably larger than the X-connector.

Consider the threaded connector in the same critical vein. Tension is transferred into the nut by shear through the threads. Threads are inherently inefficient in that they are not uniformly loaded; some of the threads carry more shear than others and extra material must be added to account for the uneven load distribution. In some cases, the nut may be sized not for the tension load that it carries but so that the nut and the wrench will survive the torque that must be applied in assembling the connector. In such an event, the threaded connector will be designed for assembly rather than operation. Also, the threaded connector carries a wrenching flat on one side that is inert when the connector is operating.

The X-connector's method of joining flanges would by itself make it attractive, but there is another independent and attractive feature in its structure. It is connected to the tube by a mechanical swage (Figure 2), which makes it possible to construct the entire system of hardened, lightweight tube material. When conventional connectors with their welded or brazed tube-to-flange joints are used, the joint is left in the annealed condition and the use of hardened tubing would be pointless. This ability to use hardened tubing will in most cases be a more significant advantage than the weight reduction of the connector itself.

These weight reduction advantages which are apparent upon such a cursory consideration made the investigation of feasibility attractive, even imperative. The feasibility investigation consisted of answering the following questions:

- How can the sleeves be swaged reliably?
- Will the primary seal perform reliably?
- How should the tube-to-sleeve swage be made structurally sound and leakproof?

The remainder of this report answers these questions by presenting the form of the feasible connector and the tooling used, opinions for future work, and the basic information on feasibility demonstration.

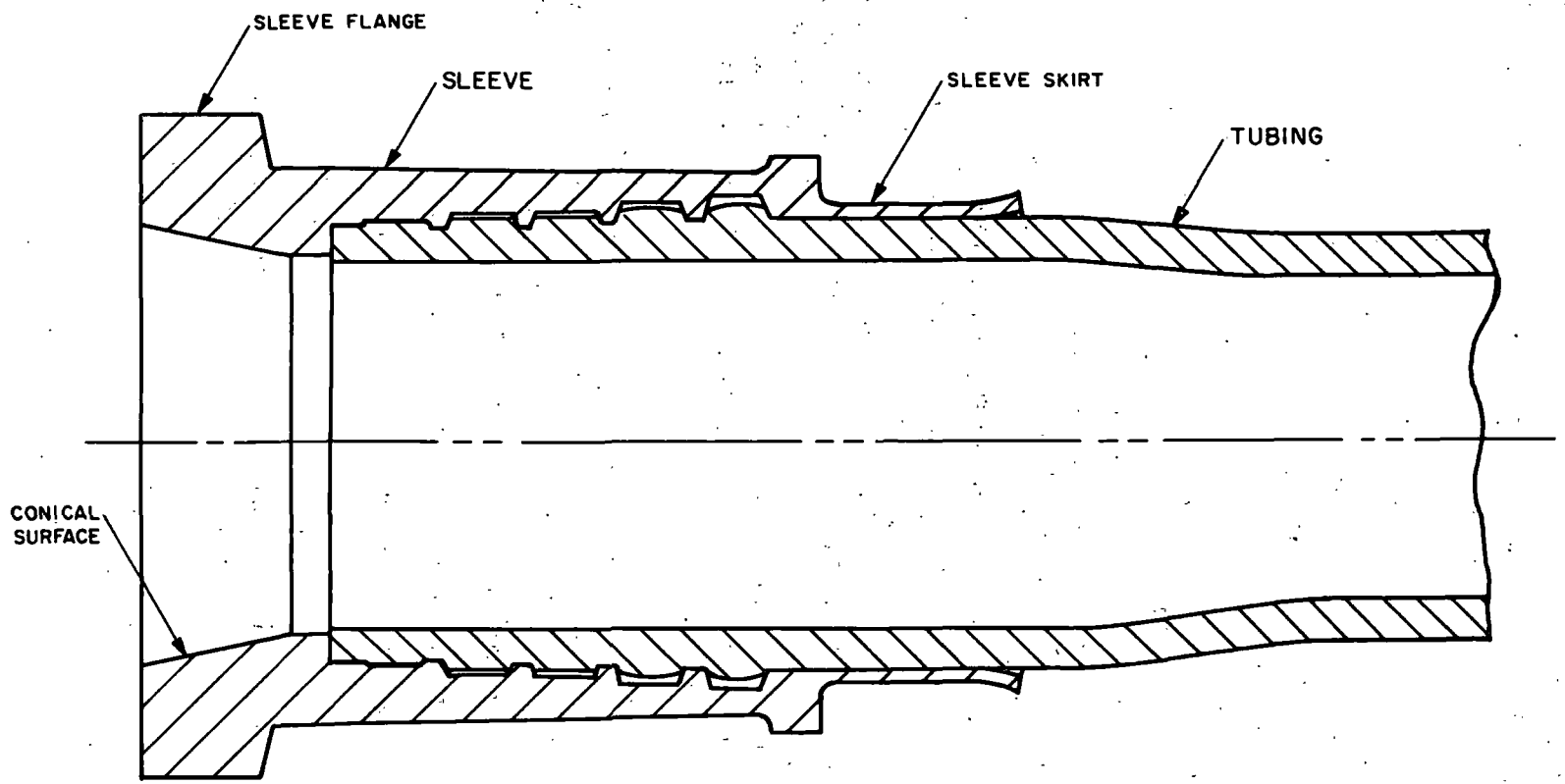


Figure 2. The Tube-to-sleeve Swage

Section 2

THE CONNECTOR AND TOOLS

THE CONNECTOR

This study resulted in the swaged connector shown in Figure 3, for half-inch tubing with a 0.058-inch wall thickness. The connector was delivered for feasibility testing at operating pressure of 4500 psi and temperature of 700°F. Similar connectors were designed for both half-inch and four-inch tubing and an operating pressure of 1000 psi. The low-pressure connectors were not manufactured or tested, however; study time was concentrated rather on the design shown in Figure 3. For detailed drawings of all of these connectors, see Appendices I, II, and III.

The name X-connector has been derived from the "X" shape of the collar cross-section before swaging. This connector is semipermanent, which simply means that it is designed to be separated only three or four times and that special tools are acceptable for assembly and disassembly. The connector parts are made of Inconel 718 and the tubing is 304L stainless steel, 1/8 hard. The inside surface of both sleeves is gold-plated to provide a caulking action, necessary because of possible scratches on the tubing. The seal is also gold-plated to provide a leakproof connection even if the primary sealing surface on the sleeve is scratched.

In assembling the connector, the tube is placed in the sleeve with its end butted against the shoulder provided in the sleeve. Then a restraining collar is placed around the sleeve, concentric with it. The tube swaging tool, which will subsequently be described, is inserted in the tube and expanded radially. Both the tube and the sleeve undergo plastic deformation, causing the sleeve to bite into the tube at the four contact rings. During this operation both the tube and the sleeve are plastically deformed throughout their entire thickness. When the tool is relaxed, the Inconel sleeve and 304 tubing go through an elastic springback. Because the Inconel has a higher yield strength than the 304, the residual stresses are such that the sleeve squeezes the tube, and the two are joined.

The collar swaging operation will usually be performed at the vehicle, the tube and sleeve having previously been swaged together during production. The collar-seal assembly is placed between the two sleeves, and the collar swaging tool, which will be described, is placed concentrically around the collar and the seal is seated. The tool's action is such as to plastically deform the collar, pushing it radially inward and driving the lips axially toward each other. The lips contact the sleeve flanges before the radial stroke of the tool is complete. From this point on the collar pinches the two flanges together with a very high axial force, leaving the two halves of the connector joined together.

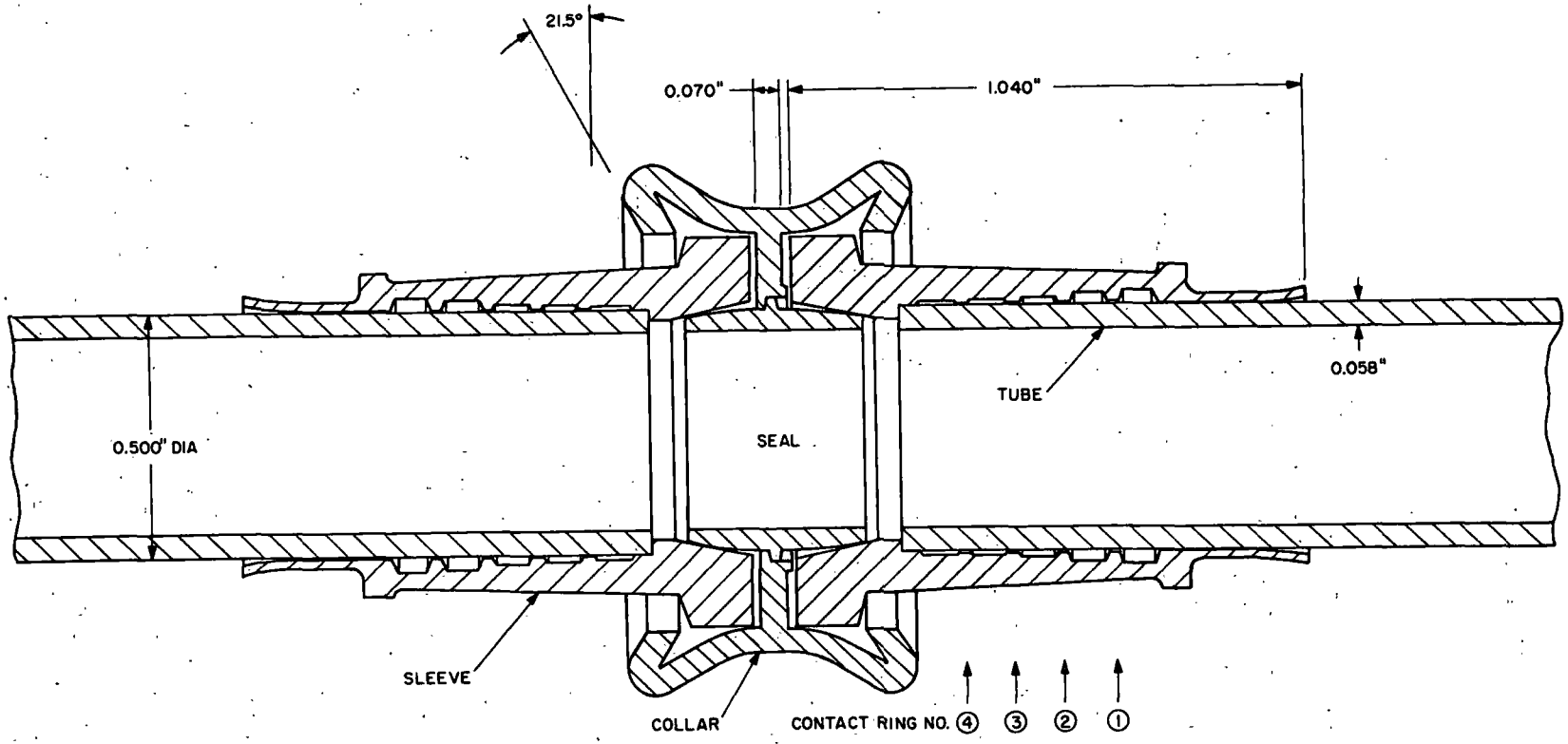


Figure 3a. The Half-inch, 4500-psi X-Connector, Before Swaging

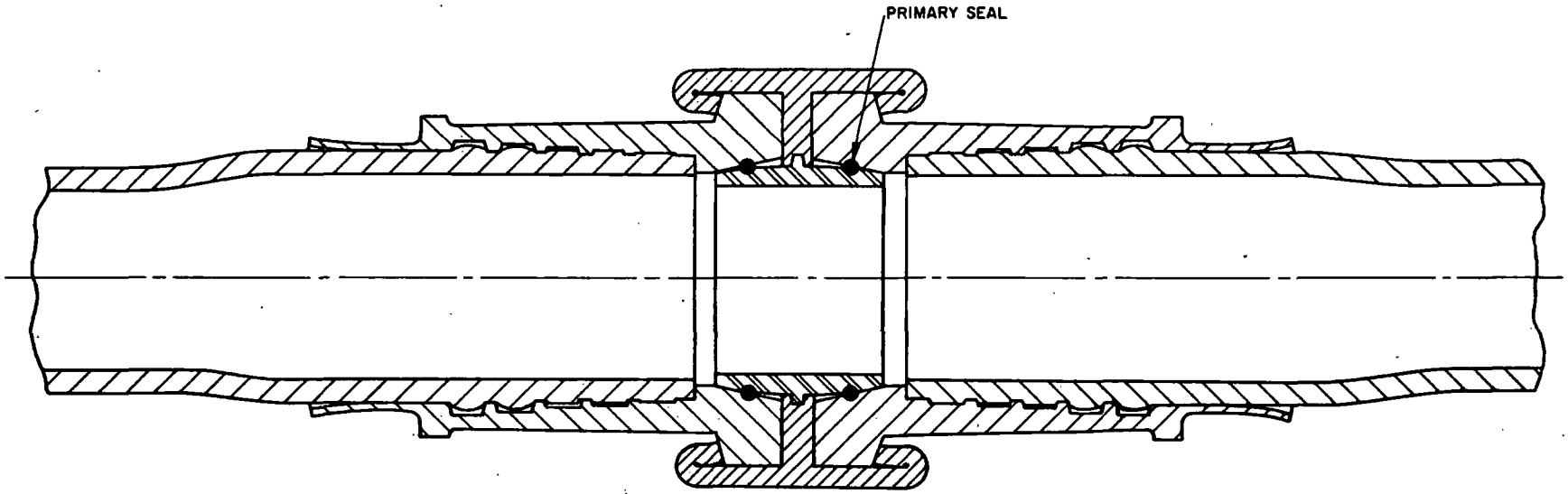


Figure 3b. The Half-inch, 4500-psi X-Connector, After Swaging

It is contemplated that disassembly be accomplished by a special unswaging tool which would bend the collar in the reverse direction. In this study, disassembly was accomplished by machining the collar off. After disassembly, the collar-seal assembly cannot be accidentally reused and must be discarded.

In its form for feasibility demonstration, the connector incorporates a number of advantages:

- An alternate load path is used to carry load through the flanges and around the seals. This is probably one of the most important principles of good connector design.
- There is a good transition section between the tube and the sleeve. This is formed by allowing the tube swaging tool to penetrate into the tube for a length greater than that of the sleeve.
- The material of the connector and the tubing is work-hardened by the swaging action.
- Under vibration conditions, some damping is provided by friction between the sleeve skirt and the tube.
- Redundant seals are provided by the four-contact swage between the tube and the sleeve. It should be mentioned, however, that redundancy would not be necessary if this joint were welded or brazed. The reasons for a swage and its advantages have already been discussed in the introduction.
- Because of the large plastic deflections which take place during the swaging operations, it is not necessary to hold close dimensional control of the tubing or the component parts of the connector.
- When the tube thickness varies, it is only necessary to use a different sleeve. The seal and collar can remain the same.
- The gold caulking provided on the inside surfaces of the sleeves and on the seal prevents leakage even when the tubing or the sleeve cone is scratched.

THE TUBE SWAGING TOOL

The tube swaging tool is shown in Figure 4 with a tube about to be swaged into the sleeve. The restraining collar is shown in the position it occupies during the swaging operation. For detailed drawings of all these parts, see Appendix I.

To make a swage, the tube is first placed in the sleeve and then over the swaging collet of the tube swaging tool. The tube is placed so that the

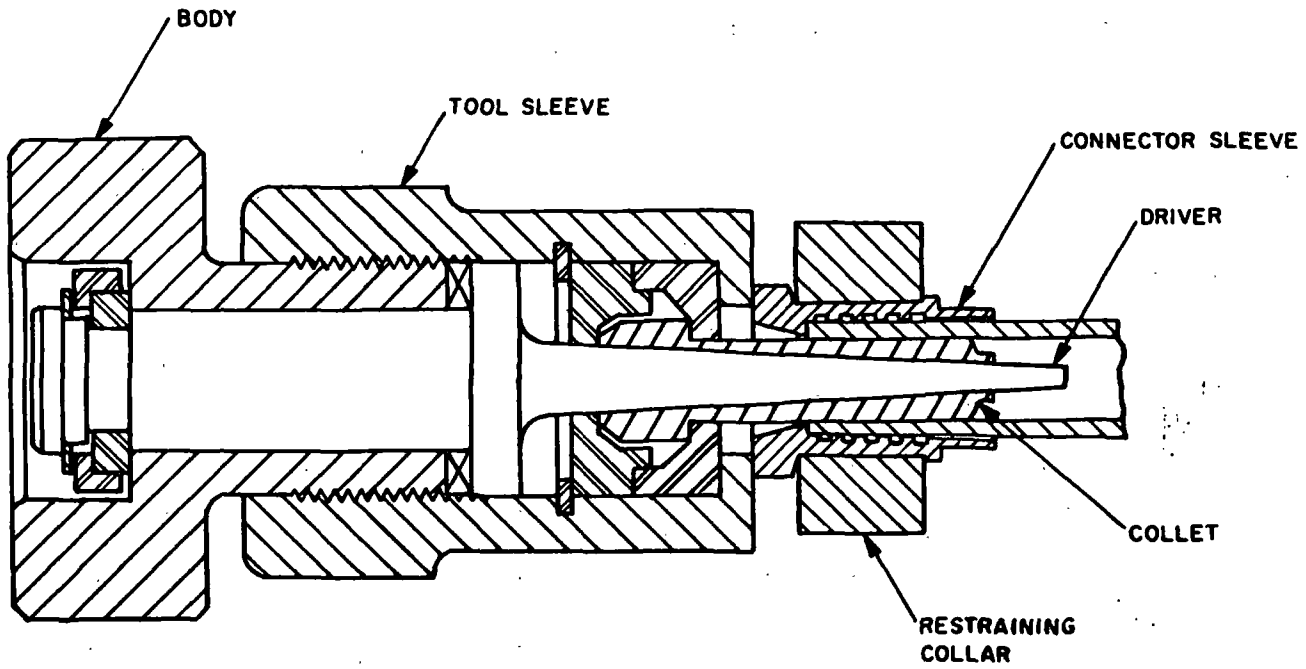


Figure 4. The Tube Swaging Tool

flange of the sleeve butts against the tool sleeve. With the sleeve of the tool held firmly, the body of the tool is then turned. The thread indicated between the body and the sleeve of the tool causes the body to move axially to the right with respect to the sleeve. In so doing, it pushes on the thrust bearing, which in turn pushes on the driver. The driver moves axially to the right and the conical section at its right-most end forces the collet sectors radially outward, swaging the tube to the sleeve. The only torque placed on the driver is that which can be transmitted through the thrust bearing. This prevents any twisting of the collet sections. When the swage is complete the collet and driver will be jammed in position and it is necessary to rotate the tool body in the opposite direction. The tool body moves axially to the left, thrusting against the retainer, which in turn pulls the driver to the left, freeing the collet so that the tool may be removed from the completed tube-to-sleeve swage.

This tool was the object of considerable study in the feasibility program. In particular, the form of the collet received a great deal of attention. A collet is manufactured by first machining a cylinder and then machining a conical hole in it to match the shape of the driver. This cylinder with its conical hole is then sawed into six equal radial sectors. From this point on in the manufacture of these collets, there were four different variations. All of these variations concerned the radius that was machined on each segment. Table 1 lists the different variations.

Table 1

COLLET RADIUS VARIATIONS

Dash Number	Collet Radius
- 4	0.209 inch
-24	0.190 inch
-25	0.244 inch
-26	0.248 inch

The dash numbers identify different details in drawing S80-0-265, in Appendix I. That drawing may be consulted for further information concerning the form and manufacture of these collets. The -26 collet was used to manufacture the 26 connectors used in feasibility testing. The swage was carried to a depth at which the diametral interference between the outside diameter of the tube and the contact diameter in the sleeve was 0.025 inch. This required approximately 12 tool revolutions after the tube first contacted the sleeve.

A study was made of the four collets in Table 1 to determine which one gave the least variation in swaging depth around the periphery of the tube. As illustrated in Figure 5, the collet swaging pressure can never be entirely uniform around the tube periphery; this is simply because there is no pressure at all on the tube in the space between the sectors of the collet. If the collet radius is smaller than the initial tube radius, then the swaging action starts at the center of a collet sector. Correspondingly, the last portion of

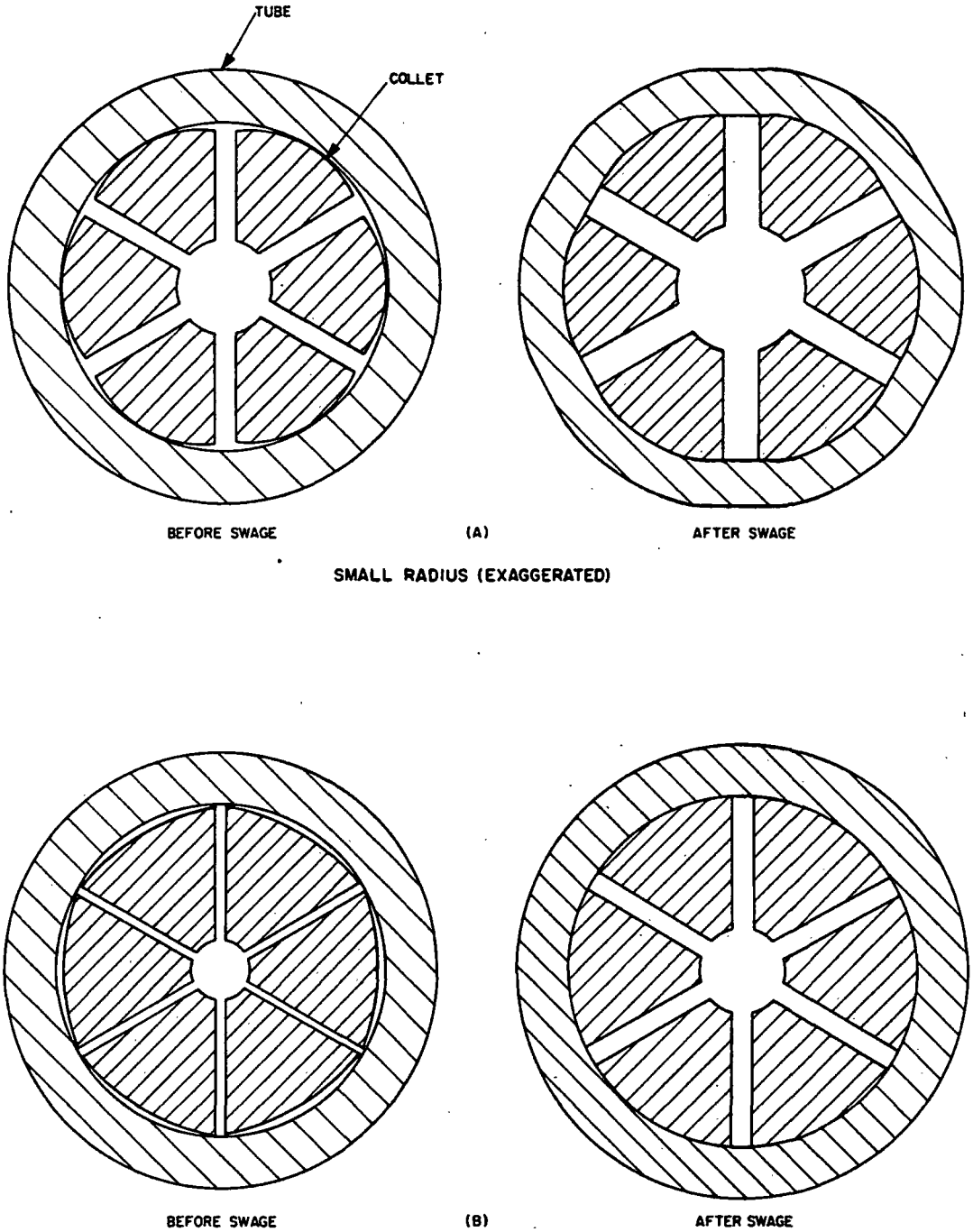


Figure 5. Peripheral Tube Swaging Variation

the tube periphery to begin swaging into the sleeve is that area located between the collet sectors. The swage resulting from the use of such a collet will look like Figure 5a. If, however, the collet radius is larger than the initial tube radius, then the swage will be initiated at the peripheral extreme of each sector rather than at its center. At the time of the initiation of such a swage, the tool will be almost entirely collapsed and there will be no gap between the sectors. As the swage starts, that portion of the tube between the sectors is swaged, and the portion of the tube at the center of each sector is not swaged until the end of the tool action. In this way, the peripheral variation of the swaging depth can be minimized, as shown in Figure 5b. If this radius becomes too large the swage will be deepest between the sectors and very shallow at the center of the sectors. The experimental study determined that the -26 collet, with its 0.248-inch radius, was superior to any of the other collets listed in Table 1.

THE EXPERIMENTAL COLLAR SWAGING TOOL

The collar swaging tool is shown in a schematic diagram in Figure 6 with a connector assembly about to be completed. In Figure 6, the sleeves and seal are shown but they are not sectioned. Figure 7 comprises photographs of the base and fingers (top) and the ring and plate (bottom).

Before the tool is used, the bottom bushing and the bottom block are bolted to the base so that the connector collar will be centered with the fingers. The plate is also bolted to the base. There are no other parts in position. A tube-sleeve assembly is dropped through the bottom bushing and a collar-seal assembly is placed so that the seal rests on the bottom connector sleeve. The top tube-sleeve assembly is then placed on the other half of the seal and the top block and bushing are slid over the top tube and bolted lightly. A tensile testing machine then applies compressive load to the top sleeve, seating the seal and driving the sleeve flanges against the collar web. The top block and bushing are bolted down to maintain this load. (This procedure for seating the seal is an experimental one. Its purpose is to measure the load required to seal. The seating can be accomplished by tightening the bolts alone.) The fingers are then inserted in the base and the ring is placed over the entire assembly, resting on the outside ends of the fingers. Compressive load is applied to the base and the ring, driving the fingers inward and plastically deforming the collar radially inward. The load required from the testing machine to accomplish such a swage is approximately 30 tons.

For the most part, collars were designed by trial-and-error testing of different configurations. One collar configuration that was tried was unsuccessful because after swaging it only gripped the sleeve by squeezing radially against the cylindrical portion of the sleeve. It did not develop any axial load against the flange of the sleeve. This flaw was not evident when the connector was first pressurized, but when it was brought up to full pressure the collar could not maintain its grip on the sleeves and the internal pressure separated the two halves of the connector, destroying the seal. This particular problem was solved by changing the angle of the collar legs from 15 degrees to 21.5 degrees (see Figure 3). This caused the legs to move more axially and less radially during the swaging operation.

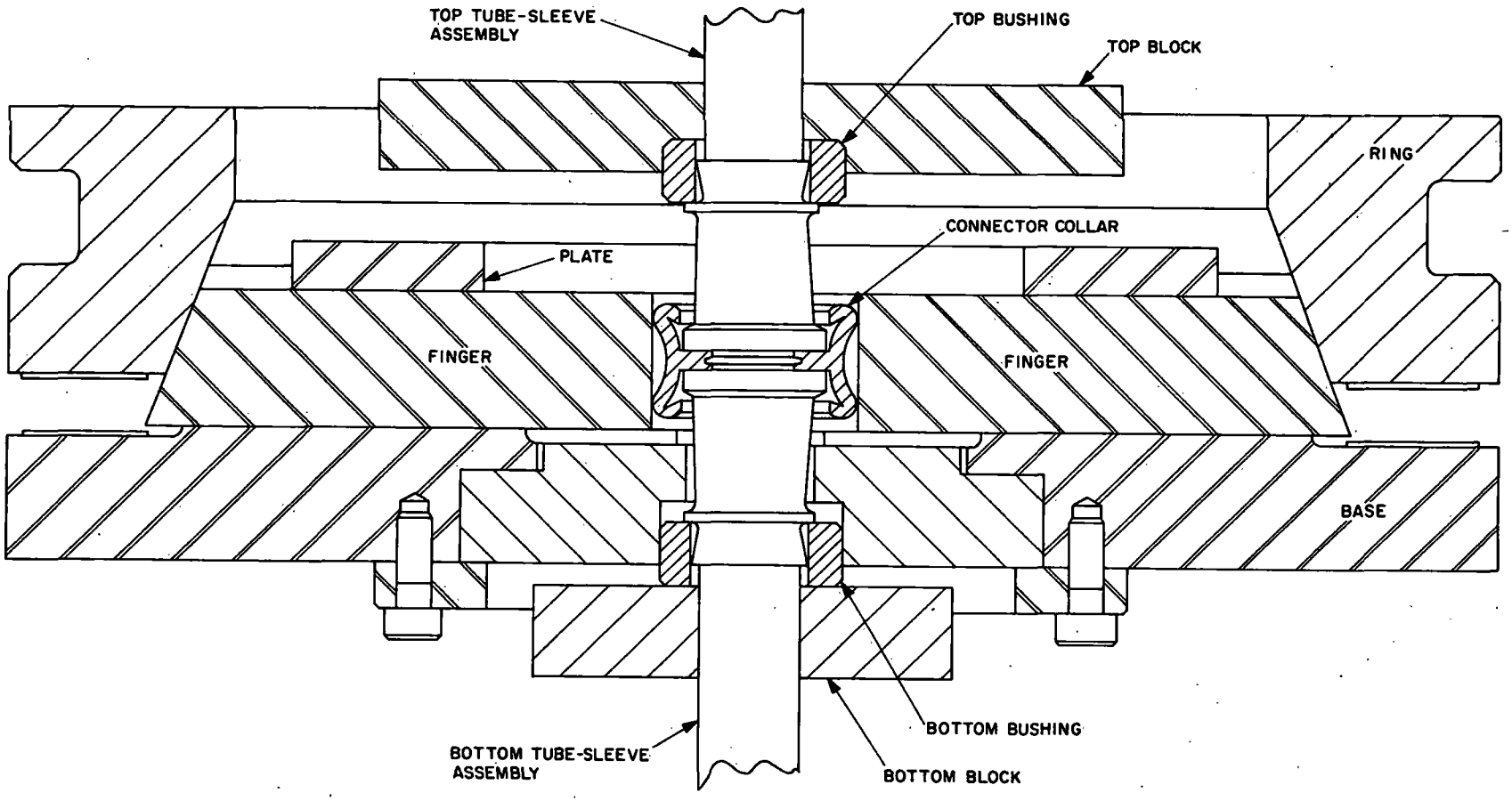


Figure 6. The Collar Swaging Tool

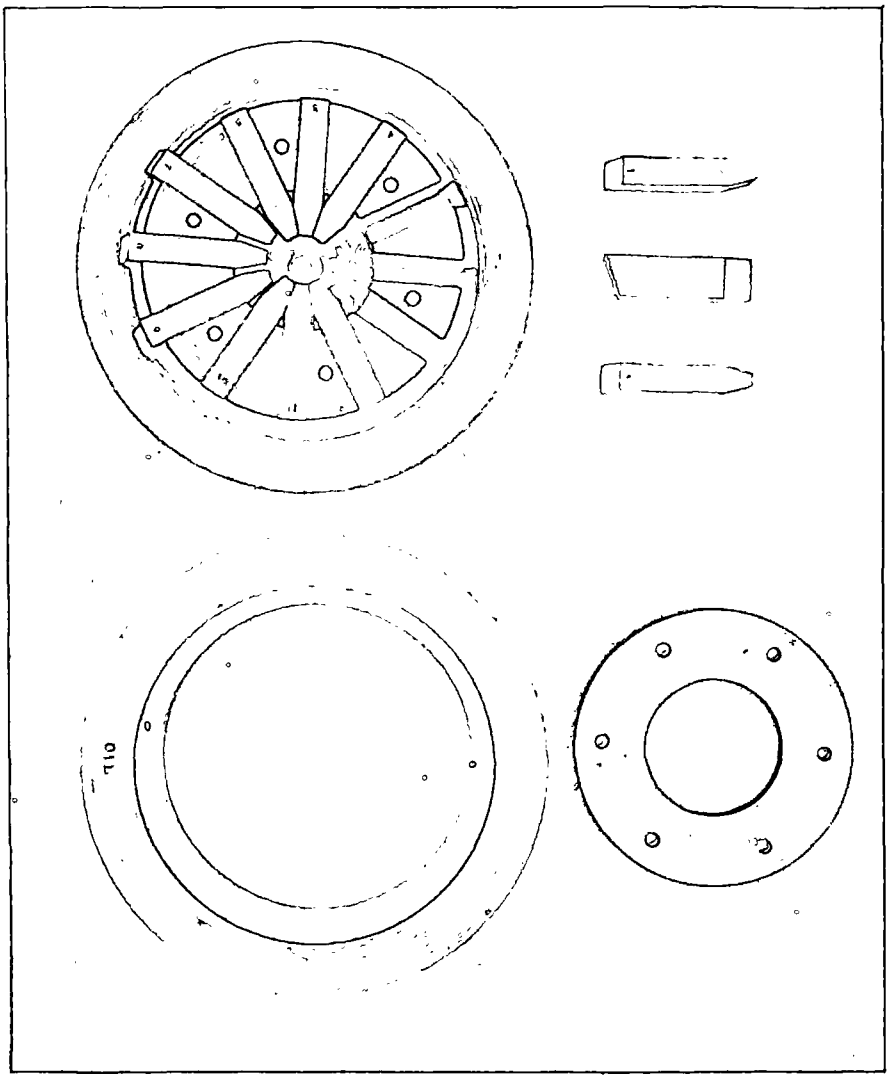


Figure 7. The Collar-swaging Tool

Section 3

CONCLUSIONS AND RECOMMENDATIONS

This study has shown that it is feasible to obtain the production design of a half-inch X-connector for 4500-psi service. This conclusion is based on the testing of 26 connectors of the form shown in Figure 3, manufactured with the tools shown in Figures 4, 5, 6, and 7. The performance of these connectors was evaluated with regard to:

- Room-temperature leakage
- Proof pressure
- Vibration at room temperature
- Burst pressure
- Tensile load
- Long-term leakage at room temperature
- Thermal shock
- Low-temperature leakage
- High-temperature leakage
- Simultaneous high-temperature vibration and leakage

More complete information on tests is presented in Section 4, "Testing for Feasibility," of this report.

In developing the production design it is recommended that continuing emphasis be placed on the vibration resistance and sealing integrity of the tube-to-sleeve swage. In the testing of the 26 connectors, the tube swage was the only feature of the design which did not perform perfectly. There has been a history of design problems associated with making this joint (see Section 5, "Development History"). The investigators do not feel that the problems of the tube-to-sleeve swage are insurmountable, because imperfect tube-swage performance in the feasibility tests arose either from correctable flaws, self-healing leaks, or poorly monitored environmental conditions.

Future work on this swage should be concerned primarily with the necessary depth of swage and the distribution of that depth. As the depth of swage increases, the sealing ability of the joint increases; but the structural integrity of the joint increases only up to some optimum swaging depth. Below that depth, the tube is subject to axial pull out; and above that depth, the material of the tube is weakened and becomes subject to cracks under bending load. With respect to distribution of swaging depth, it is obviously desirable to have the swage uniform around its periphery. It is also desirable to have the depth of swage and the sleeve cross-section designed for maximum failure resistance. In the present study, the axial distribution of the swaging depth

was such as to minimize the possibility of tube pull-out; each contact ring is supposed to take up an equal part of the tensile load. The axial variation of the sleeve thickness and diameter offers a similar opportunity for apportioning the bending load between contact rings. Leakage possibilities and cost must be kept in mind in any such attempt.

The resolution of these problems seems to be most easily arrived at through the application of an intelligent trial-and-error process in designing the tube-to-sleeve swage tool. The varying parameters in such a trial-and-error process should be:

- Curvature of the swaging collets (affects radial distribution of contact penetration into the tube)
- Shape of the restraining collar and connector sleeve (affects axial distribution of contact penetration into the tube)
- Tool turns during forming (affects average depth of contact penetration into the tube)

It is, of course, understood that production design should be accompanied by the development of swaging tools for field use. The collar swaging tool, in particular, was never intended for field use and is unsuitable for such in its present form (see Figures 6 and 7). A preliminary study, of tools suitable for portable use was carried out under this contract (see Figure 13 of reference 6).

Section 4

TESTING FOR FEASIBILITY

TEST RESULTS

The conclusion for feasibility stated in Section 3 was based on the testing of 26 connectors. All 26 of these connectors were subjected to tests by Parker Aircraft Company. Twenty of them were later delivered to General Electric and subjected to tests designed to simulate actual connector environments.

Connectors were tested by Parker Aircraft Company under the following conditions:

Test	Goal*
a. Room-temperature leak	Room-temperature leakage less than 10^{-6} atm-cc/sec at 4500 psi internal pressure.
b. Proof pressure	Room-temperature leakage less than 10^{-6} atm-cc/sec at 4500 psi internal pressure following previous pressurization to 9000 psi.
c. Vibration	Room-temperature leakage less than 10^{-6} atm-cc/sec at 4500 psi after 10^{6} cycles of 30,000 psi bending stress at room temperature with no pressurization.
d. Burst	Structural integrity satisfactory after application of 18,000 psi internal pressure at room temperature.
e. Tensile load	Structural integrity satisfactory until application of 8900 lbs of axial load at room temperature and zero internal pressure.

Connectors were tested by General Electric Company under the following conditions:

f. Long-term leak	Room-temperature leakage less than 10^{-6} atm-cc/sec at 4500 psi internal pressure maintained continuously for five weeks.
g. Thermal shock	Structural and leak integrity satisfactory after immersion of test-equipped connector in liquid nitrogen at 4500 psi internal pressure.

*Leakages stated refer to helium test gas used.

Test	Goal
h. Low-temperature leak	Leakage less than 10^{-6} atm-cc/sec at -320 F temperature with internal pressure of 4500 psi.
i. High-temperature leak	Leakage less than 10^{-6} atm-cc/sec at + 700 F temperature with internal pressure of 4500 psi.
j. High-temperature vibration and leakage	Leakage less than 10^{-6} atm-cc/sec at +700 F with 4500 psi pressurization and 24,000 psi bending stress for 10^{6} cycles. No end restraint.

Table 2 is a summary of results obtained from all these tests. A blank in the table indicates that the test was not performed on a particular connector. A zero in any column having units of leakage indicates that there was leakage of less than 10^{-6} atm-cc/sec.

In Table 2 there are some results which, if taken superficially, would indicate poor performance for connectors F106, F109, F111, and F130. Leakages were measured above the acceptable value of 10^{-6} atm-cc/sec. A discussion of the results obtained with these connectors follows.

- F106 -- The leak indicated at room-temperature pressurization (Test a) was at the fourth land on one-half of the connector only. There was no leakage indicated elsewhere in the connector when it was subjected to a bubble test. It should be noted that the leak ceased after the connector was exposed to vibration tests. This seemed to be a feature of the X-connectors in tests performed throughout this development program; a leak occasionally appeared in tests performed immediately after assembly of the connector and disappeared after vibration tests. The suspected reason for this is that the vibration causes minute movements which tend to seal the small cracks and fissures in the tube surface which are causing the leak. At any rate, it is important to note with this particular connector that the initial leak did not denote a crack in the tube or sleeve, or any other serious type of structural flaw caused by the swaging operation.

- F109 -- The word "bubbles" in Table 2 indicates that the leak in this connector under certain tests was so severe that a stream of bubbles could be detected when the connector was pressurized and immersed in an alcohol bath. It is usually thought that this latter type of test can detect leaks of magnitude greater than 10^{-4} atm-cc/sec. Since the pressure during this bubble test was only 300 psi, it is safe to say that the leak at full pressurization (4500 psi) would be considerably greater than 10^{-4} atm-cc/sec. The leak occurred across the first contact ring (see Figure 3). As mentioned

Table 2

TEST SUMMARY: HALF-INCH, 4500-PSI X-CONNECTOR

Connector Serial Number		(a) Room-temperature Leak (10^{-6} atm-cc/sec)	(b) Leak After Proof Pressure (10^{-6} atm-cc/sec)	(c) Leak After Room-temperature Vibration (10^{-6} atm-cc/sec)	(d) Burst Pressure Survived (psi)	(e) Tensile Load at Failure (lbs)	(f) Long-term Leak (10^{-6} atm-cc/sec)	(g) Integrity After Thermal Shock (OK/NOK)	(h) Low-temperature Leakage (10^{-3} atm-cc/sec)	(i) High-temperature Leakage (10^{-6} atm-cc/sec)	(j) High-temperature Vibration and Leakage (10^{-6} atm-cc/sec)
Not delivered to General Electric Company	F105	0		0							
	F106	390.		0							
	F108	0		0		8900					
	F109	Bubbles		Bubbles							
	F110	0		0	21500						
	F111	0		Bubbles							
	F114	0	0					OK	0	0	0
	F116	0	0					OK	0	0	0
	F117	0	0					OK	0	0	
	F120	0	0				0				
	F121	0	0				0				
	F122	0	0				0				
	F123	0	0				0				
	F124	0	0				0				
	F127	0	0					OK	0	0	
	F128	0	0					OK	0	0	0
	F129	0	0					OK	0	0	
	F130	7.2	0					OK	0		
	F131	0	0					OK	0	0	0
	F132	0	0					OK	0		
	F133	0	0					OK	0		
	F134	0	0					OK	0		
	F135	0	0								
	F136	0	0								
	F137	0	0								
	F138	0	0								

earlier, this contact ring is believed to be the least reliable for sealing, its primary purpose being to transfer structural load from the tube into the sleeve. It cannot be concluded from this test that any of the other contact rings would have leaked simultaneously.

Although it is not evident from Table 2, the condition of the F109 connector deteriorated considerably during the vibration test (Test c). A crack approximately 1/4 inch wide occurred in the tubing under the sleeve skirt, and a cross-sectional microexamination of the tubing after failure showed that the crack started at the penetration point of a machining groove in the inside of the sleeve skirt. An examination of this inside surface of the skirt revealed that the skirt was noticeably rougher than other sleeves which had been used. It is believed that this vibration failure can be attributed to the rough finish. An engineering change was therefore issued, and connectors F114 through F138 were manufactured with a 20-microinch finish on the surface instead of the previous 32-microinch finish.

- F111 -- This connector was subjected to an alcohol bath submergence. It showed bubbles after 734,000 cycles of vibration. At approximately 350,000 cycles of vibration the strain gage leads attached to this connector had failed. As a result, from approximately 350,000 cycles to 734,000 cycles the vibration stress level in this connector was highly uncertain. The stress was being measured by a very crude type of displacement gage during this period. It is the opinion of the research investigators that the vibration test of this connector is inconclusive.

- F130 -- This connector leaked an excessive amount when exposed to room-temperature pressurization (Test a). It was then exposed to proof pressure but was not retested for leakage at operating pressure by Parker Aircraft Company (all other connectors in the list from F114 through F138 were so tested by Parker Aircraft Company). Upon pressurization to 4500 psi at room temperature by General Electric Company the connector showed zero leakage. It is possible that handling and shipping shocks or the process of raising the connector to 9000 psi during the proof-pressure test sealed the small leak.

In all cases of these unfavorable results, it is possible that the connector:

- might have operated satisfactorily in service
- failed because of a flaw which was corrected in subsequent connectors, or
- failed under such conditions as to make the test inconclusive.

In spite of the extenuating circumstances surrounding these negative test results, they still must be regarded with caution. For this reason, it has been

recommended in Section 3 that continuing effort be applied to the development of a tube-sleeve swage which is leakproof and resists the specified vibration environment without any qualification.

In some respects, the X-connector design surpassed expected performance. The one connector subjected to burst tests surpassed its requirement by far. The burst pressure was 18,000 psi; the connector survived pressurization to 21,500 psi and showed zero leakage after cleaning, drying, and repressurization to 4500 psi. In tensile tests the tubing yielded before the tube pulled out of the skirt. Thus it is apparent that the connector does not disturb the axial strength of the tubing in which it is placed.

The results of the high-temperature pressurized vibration tests (Test j) showed complete success with the four connectors tested. It should be noted that there were three stress components in these tests, two of them due to the internal pressurization:

$$\sigma_{\text{axial, cyclic}} = 24000 \text{ psi}$$

$$\sigma_{\text{axial, steady}} = 9000 \text{ psi}$$

$$\sigma_{\text{hoop, steady}} = 18000 \text{ psi}$$

Thus this test, with its superimposed, steady, two-dimensional stress, was more stringent than the bending stress alone would indicate.

TEST PROCEDURES

The connectors tested in this study looked like that shown in Figure 3b. The total length of the assembly, including the tube, is 16.16 inches. A fitting is welded to the end of each tube for use by Parker Aircraft Company as a convenient connection for pressurizing the interior of the tube-connector assembly. This fitting utilizes an O-ring pressure seal. For Parker Aircraft Company's work this was satisfactory since they did not perform any tests at high temperatures. General Electric's tests, however, involved very low temperatures and very high temperatures, at which the O-ring seal would not have been satisfactory. For this reason the fittings were welded closed on the connectors delivered to General Electric and a hole was drilled axially through one end of the fitting. In the General Electric Company tests the pressure supply tube was inserted in this hole and welded to the fitting.

An examination of Figure 3 will show that the X-connector has four leak paths in parallel: one through each tube swage, and one on either side of the seal where it butts against the conical surface of the sleeve. When the connector is used in actual service, each of these leak paths has multiple seals in series. In the case of the tube-to-sleeve swage, there are six seals in series: one at the tube end where it butts against the shoulder in the sleeve, four at the contact rings, and one at the skirt. To leak through the primary sealing area, the gas must first leave the interior of the tube, pass through

the seal proper, and then pass through the seal formed where the collar lips are pushed against the sleeve flanges. In actual practice this redundancy is excellent. In testing, it is very troublesome. The reason is that each seal or resistance to flow is separated from the adjacent seal by a cavity. If a leak is to develop, then it must leak through the first seal in the series, charge up the first cavity to pressure, and then begin to leak through the second seal. The significance of this phenomenon (Ref. 4) is that a true leakage test for a connector must last for a time equal to the connector's lifetime or until the leak reaches steady state, whichever is shorter. The expected lifetime for the X-connector could be of the order of several months. A calculation for the leakage through the tube-to-sleeve swage indicated that the leak would not reach steady state for a period of one to five weeks. Since five weeks is obviously too long a time for one leakage test on one connector, some compromise had to be made. So-called "leakage monitoring holes" were drilled through the connector solely for test purposes. In all connectors except those used in the long-term tests (F120 through F124) these leakage monitoring holes were drilled in both sleeves, between the third and fourth contact rings. This was done for both halves of each connector. Since no hole was drilled through the tube, any leak through the tube-sleeve swage must flow first through the seal formed by the tube end and then through the seal formed by the fourth contact ring before passing out to be detected. Leakage monitoring holes in the collar were drilled radially inward through the collar shell. The sleeve faces were cut with a radial groove where they bear on the collar web. In this way leakage through the primary seal was directly exposed to detection, with no time lag.

It will, of course, strike the reader that this makes testing much easier, but at the same time it will be noticed that the measurement is overconservative; a leak passing through the tube end and contact number 4 will be larger than a leak which must pass through the tube end, all four contact rings, and the skirt contact. It was for this reason that the long-term tests were run. They gave a true picture of the leakage obtained with a connector in static room-temperature service.

Parker Aircraft Company Tests

Before shipping to General Electric Company, the Parker Aircraft Company conducted various combinations of tests on 26 connectors which were very close to the final configuration defined in Section 2.

Tube-sleeve swages were tested before their assembly, and each assembly to be tested was placed in the tool shown in Appendix I (drawing No. S65-0-1149). The interior of the assembly was pressurized through the O-ring fitting on the end of the assembly. The cavity between the exterior of the sleeve and the interior of the fixture was evacuated and leakage could be read. No results from this preliminary test are shown in the test summary (Table 2) because it is not a true test of the connector as used in service. It is worth noting, however, that in all 26 connectors of Table 2 (except F120 through F124, on which this test was not performed) there was zero leakage for every tube-sleeve assembly.

After these tube-sleeve assemblies had been swaged together using a collar-seal assembly, it was possible to perform the room-temperature leak tests and tests for room-temperature leakage following proof pressurization (Tests a and b, respectively, in Table 2). For these tests the full connector assembly was placed in the fixture shown in drawing 5669058, Appendix I. The pressurization fitting at one end was closed with a plug and the interior of the connector pressurized through the pressure fitting at the other end. The fixture was then evacuated and the total of leakage through the tube-sleeve swages and the primary seal was read. To perform these tests, the internal pressure was brought up in steps and applied for five minutes at each pressure step. The pressure steps were 0, 4500, 9000, 4500, and 0 psi, in that order. The results published for Test a are those leakages read for the first five minutes at 4500 psi and the results published for Test b are those leakages read when the connector was pressurized to 4500 psi for the second time. It was assumed that five minutes is sufficient time for the leak at the tube-sleeve swage to reach steady state. This small amount of time is probably reasonable because the cavity between the tube-end and contact number 4 is very small after the tube has been swaged.

There was one deviation from this pattern. Connector F130 was pressurized only at 0 and 4500 psi while attached to the leak detector. When the 7.2×10^{-6} atm-cc/sec leak was discovered, the connector was removed from the fixture and placed in an alcohol bath with internal pressurization to 9000 psi. At this pressure, one bubble was detected every three seconds. The connector was not returned for 4500-psi testing after the 9000-psi exposure by Parker Aircraft. (It was, however, tested at 4500 psi by General Electric Company. No leak could be detected.)

The vibration test and ensuing leakage measurement (Test c in Table 2) were then performed by removing the connector from the leak test fixture and placing it in a vibration set-up similar to that used by the General Electric Company, which will be described in the next sub-section. The vibration endurance of plain tubing was also established (see Section 5, "Development History"). Prior to placement in the vibration fixture, a strain gage had been mounted on the tube as close to the connector as possible. This strain gage was calibrated by placing a known weight on the span formed by the tube-connector assembly, the stress produced by this weight was calculated as if the weight hung on a continuous span of tubing, and the gain of the strain gage system was then set to read this calculated stress. When the calibration was complete, the connector was vibrated at resonance for one million cycles at 30,000-psi bending stress as measured by the strain gage. This 30,000 psi goal is in agreement with a rule of thumb from Reference 4 which states that the fatigue strength at the interface of the tube and connector should be approximately one-third the yield stress of the tubing. The 30,000 psi goal is approximately one-third of the yield strength of 85,000 to 100,000 psi measured for the tubing. During the vibration test, the connector was not pressurized. After 10^6 cycles of bending, the connector was removed from the vibration stand, placed in the leakage test fixture, and pressurized for

five minutes, and its leakage was read. In cases of gross leakage or obvious structural failure, the connector was immersed in an alcohol bubble bath for the purpose of locating cracks before sectioning.

A burst test (Test d, in Table 2) was performed on connector F110. It was subjected to internal hydrostatic pressure, the medium being alcohol. Pressure was applied at the rate of 20,000 psi per minute from proof pressure (9000 psi) to burst pressure (18,000 psi). No visible leakage occurred after five minutes at 18,000 psi and the pressure was increased to 21,500 psi, where no leakage was evident. The connector was thoroughly dried and retested with the helium mass spectrometer and showed no leakage from zero to 9000 psi. A tensile strength test (Test 2, in Table 2) was performed on connector F108. The tubing pulled out of one sleeve at 8900 pounds of load; it had noticeably yielded prior to separation. The 8900-pound load was equivalent to 109,000-psi tensile stress in the tubing, a value slightly above the tubing yield strength.

General Electric Combined Environment Tests

The object of these tests was to measure X-connector leakage under conditions which simulated the operating environment more closely than previous tests did. All connectors tested by the General Electric Company were outfitted with bellows and end caps (shown in Figures 8 and 9), which formed the vacuum chamber necessary for leak detection but did not add significant weight to the connector. The bellows is highly flexible in comparison to the connector and adds no stiffness to the span. It was necessary to have this arrangement in place in order to take leakage readings while the connector was being exposed to environmental conditions such as high temperature, low temperature, or vibration.

Those connectors undergoing long-term tests (Test f, in Table 2) were not outfitted with thermocouples or strain gages but were suspended from their pressure supply manifold, which was of welded construction as shown in Figure 10. The connectors were pressurized through this manifold continuously and without any interruption for 62 days. At intervals (several times a day for the first week and only once a week during the last two weeks) leakage was read for each connector separately. Readings were taken by connecting the leak detector to the large rubber hose protruding vertically on the right side of each connector in Figure 10. It was noted early in this test that approximately one hour was required to achieve the vacuum for each connector. By closing the end of each hose with a valve, however, vacuum could be maintained continuously in the bellows and only about five minutes was required to pump each system down before measurement. At no time during the 62 days of this test was any leakage read above the background level of the leak detector.

Thermal-shock test and the low-temperature leakage test (Tests g and h, respectively, in Table 2) were performed by immersing the connector with its bellows assembly in liquid nitrogen. The connector was suspended from

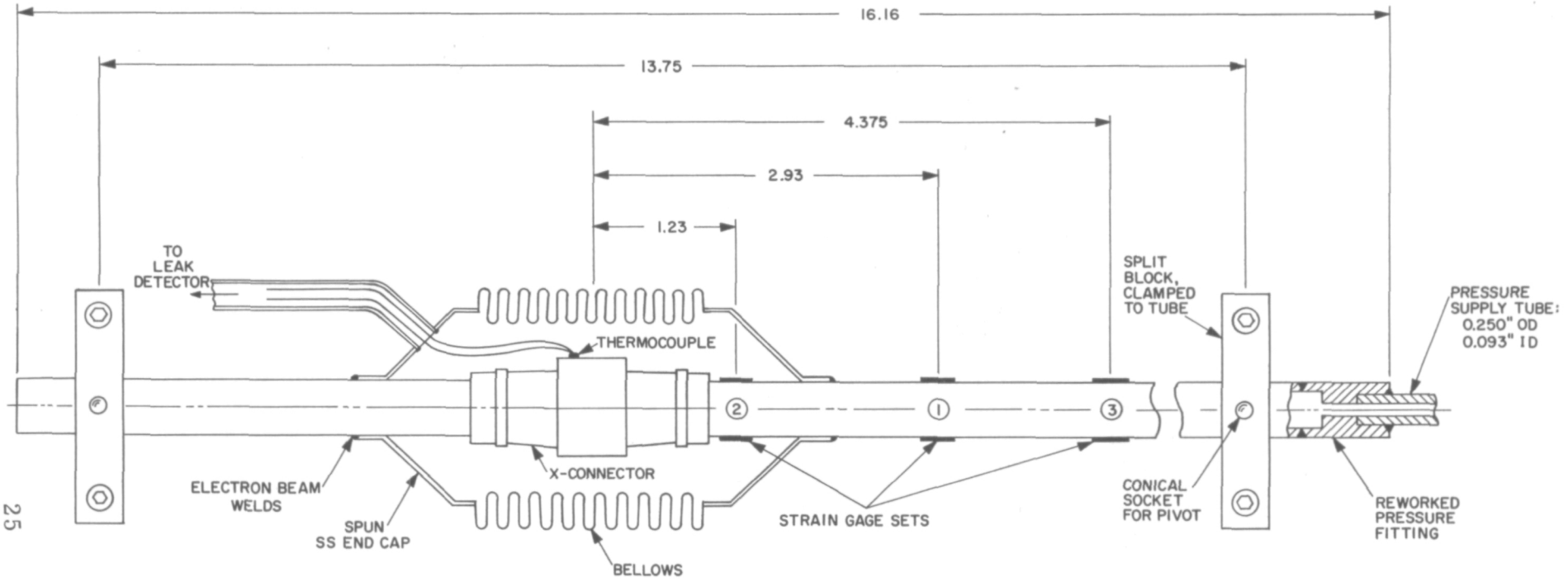


Figure 8. The X-Connector and Its Test Accessories

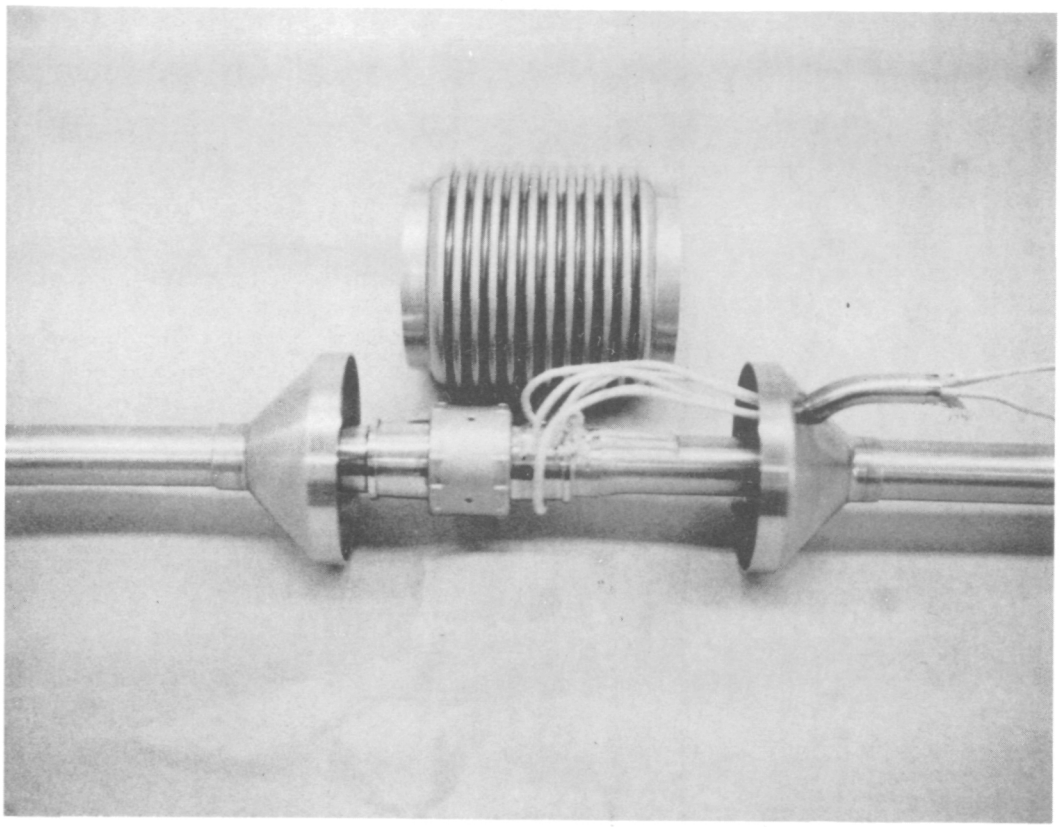


Figure 9. Connector F116 With Test Accessories

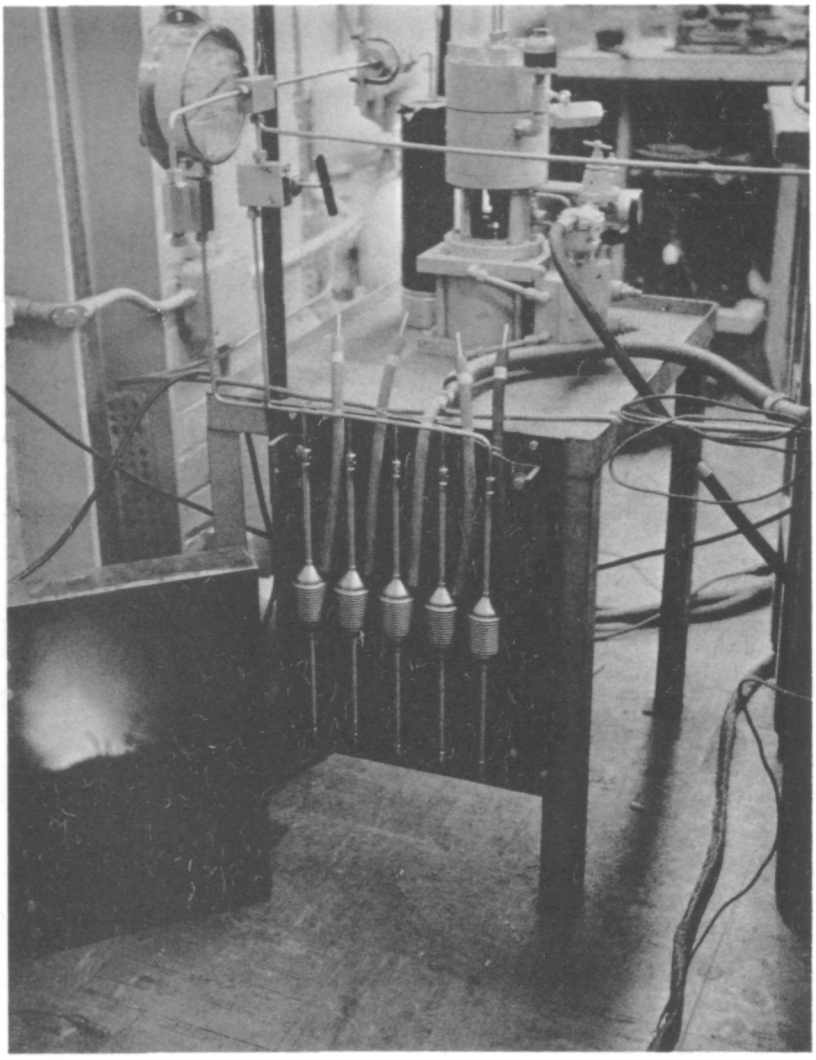


Figure 10. Long-term Test Equipment and Connectors

its pressure supply tube above an insulated container filled with liquid nitrogen, as shown in Figure 11. The connector was pressurized and the leak detector connected to the bellows port. The container was then lifted into the position shown in Figure 12 and maintained there for approximately one hour. During that period, the temperature of the connector collar and the nitrogen bath were continuously recorded. Approximately six minutes were required for the thermocouple to register 100 F temperature drop. The test continued until the collar temperature equalled the nitrogen temperature for a period of fifteen minutes. Leakage was recorded throughout this period. The maintainance of structural integrity was inferred from the absence of any significant leakage.

The high-temperature leakage test and the high-temperature vibration and leakage tests (Tests i and j, in Table 2) were performed by placing the connector test assembly in the vibration fixture shown in Figures 13 and 14. The shaker frame for this fixture is shown at the bottom of Figure 13 with the accessory table bolted to it. Mounted on the table is half of the explosion shield, shown at the left, and the oven. The oven is shown opened so that the connector assembly can be seen as it was tested. During operation, the two halves of the oven are pivoted and bolted together. Between the shaker frame and the accessory table, the end of a heavy beam can be seen. This heavy beam is the driven element of the shaker. Extending vertically up from the driven member is a slender structural member in which the X-connector assembly is clamped. The clamp squeezes the tube but is pivoted to the slender structural member to allow the ends of the tube to rotate freely in an up-and-down direction.

The strain gages at positions 1 and 3 are wrapped with reflective aluminum tape before the connector is placed in the fixture. The strain gages are also protected from the radiation of the oven by a long tube which is concentric with the connector tube and attached to the oven . Only after considerable difficulty with strain gage failures was this method of protection for the strain gages devised; it is absolutely necessary to protect these gages from direct incident radiation of the oven. The thermocouple leads are brought out from the vacuum envelope by a glass connector. The pressurization line for the connector is welded to the end of the connector tube. The line, not shown in Figure 13, was constructed of high-pressure tubing bent into a large loop approximately two feet in diameter. By this means the elastic effects of this pressure line on the vibration of the tube-connector assembly were minimized.

At the start of the test the heater is turned on and the assembly is brought up to temperature. Temperature is continuously monitored with recording equipment. After the temperature of the thermocouple (Figure 8) has reached 700 F, a predetermined load is exerted vertically upward on the tube connector span by a spring scale. This load and the stress produced at position 1 have been previously related by calculation. The gain of the strain gage system for strain gage No. 1 is set to the predetermined value; thus that gage is calibrated. As a backup in case strain gage No. 1 should fail during the vibration test, strain gage No. 3 is also set to the same value; and thus, from a reading at gage 1 or a reading at gage 3 it is possible to determine the stress

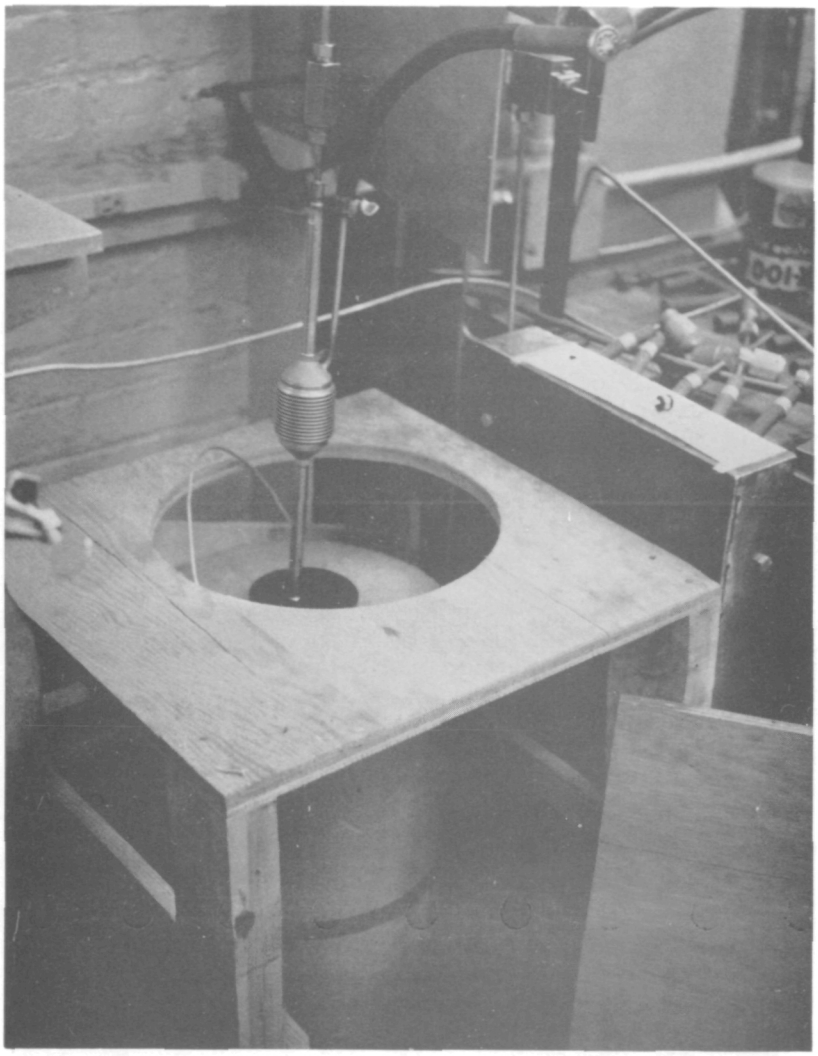


Figure 11. Cold Test Before Immersion

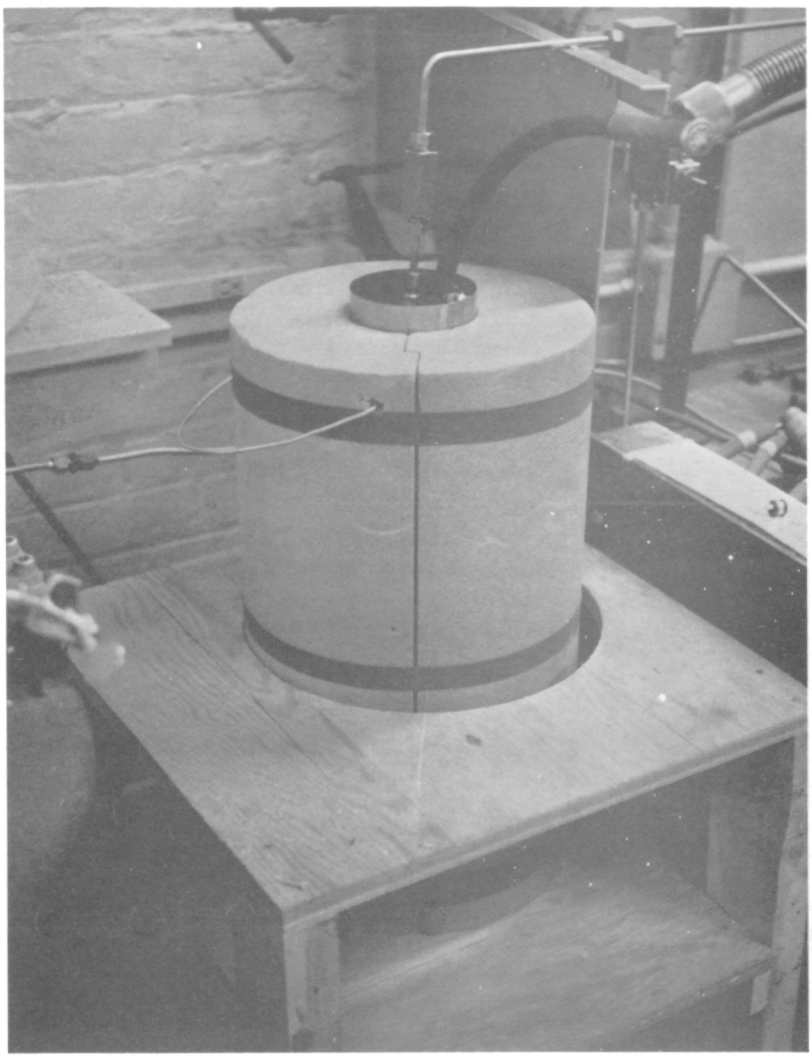


Figure 12. Cold Test After Immersion

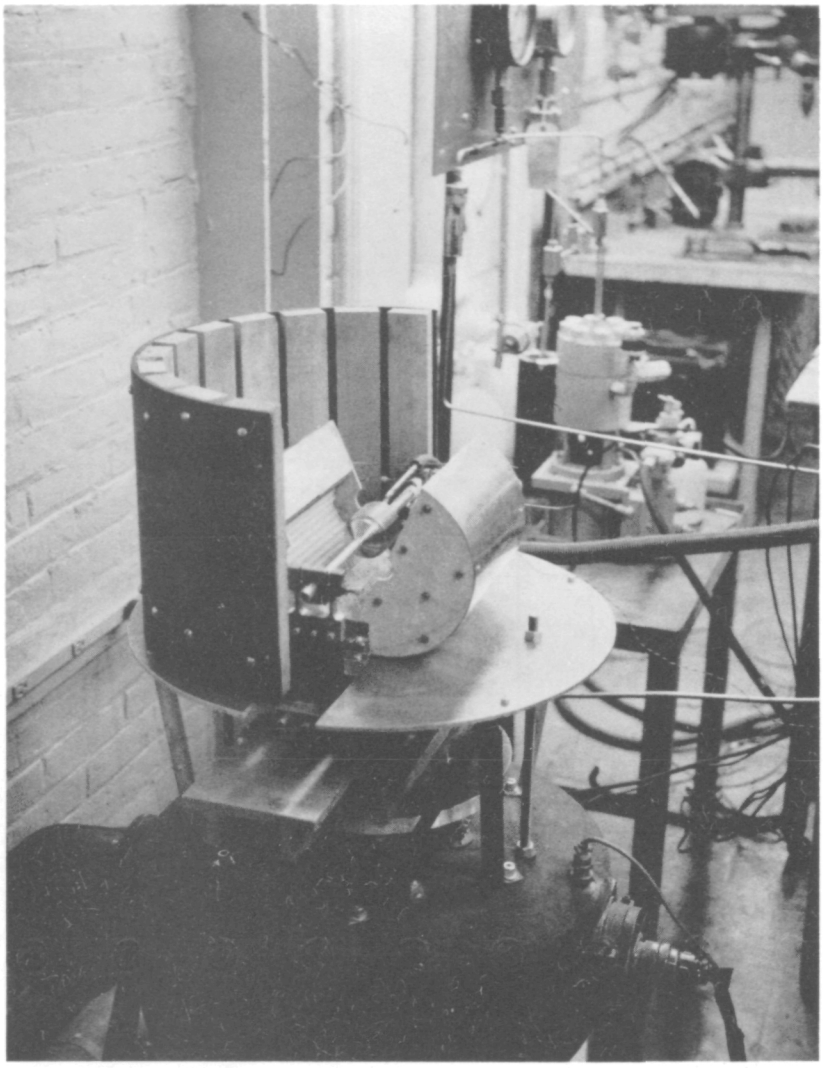


Figure 13. Combined High-temperature and Vibration Test

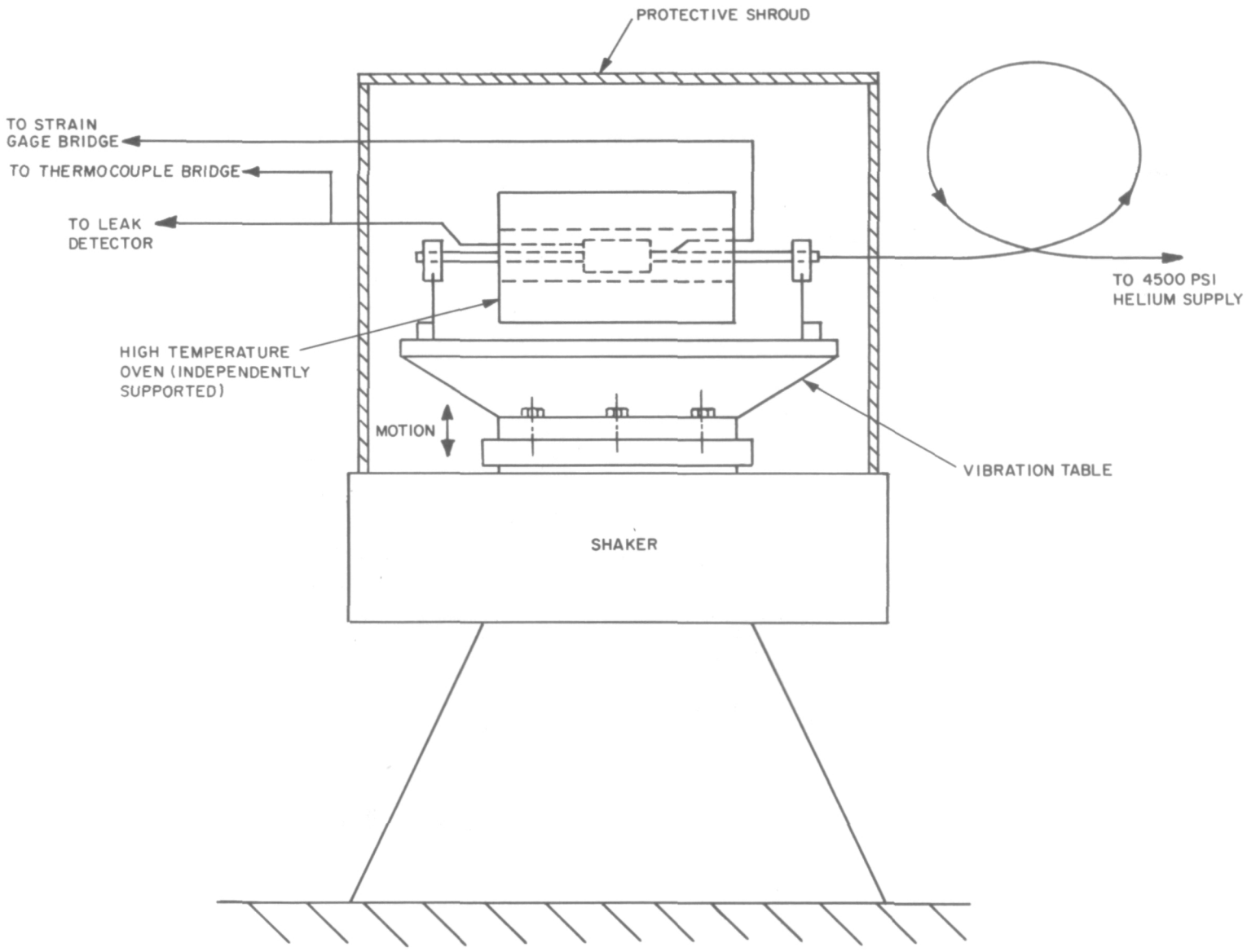


Figure 14. Schematic Diagram of High-temperature and Vibration Test

at position 1. The stress at position 1 has been previously related to the stress at position 2 by an experimental program which will be described subsequently in this Section. Stress at position 2 then can be determined indirectly by either of two strain gages.

After the strain gages have been calibrated, the connector assembly is pressurized for 15 minutes and the leakage is read. The reading is entered as that for Test i in Table 2. The strain gages will not be disturbed by pressurization of the system. They have been arranged so that the top gage reads plus for tension, the bottom gage reads minus for tension, and their output is summed. Thus they give no reading at all when the tube is placed under tension by the pressure reaction.

Immediately after the leakage reading is obtained, the vibration machine is turned on and tuned to the resonant frequency of the tube-connector assembly (approximately 175 cps). The 24,000-psi bending stress at 700 F was considered to be equivalent to 30,000 psi at 70 F (Ref. 5). Table 3 shows the schedule of stress and cycles which was followed.

The goal to be obtained was the 24,000-psi bending stress at position 2. The gradual buildup of the stress was found to be necessary after attempts were made to perform high-temperature vibration tests on connectors F117, F127 and F129. When this test was attempted on these connectors, cracks developed through the tube in the exact position of the electron beam weld that fastened the conical end caps to the tube (see Figure 8). It was reasoned that the electron beam weld had been made with improper control and that the tubing material had annealed during the welding process. Being annealed, it was weak and failed at less than 10^6 cycles. Such a failure, of course, indicates faulty test procedure and is no indication of poor performance on the part of the connector. Hypothesizing that this was the cause for the tube crack, it would follow that the tube could be rehardened locally by building up the stress gradually and strengthening the annealed region before it had the opportunity to crack. This was evidently correct, because when it was tried on F128 and F131 the test proceeded without spurious failures. There was no evidence of cracking with connectors F114 and F116, probably because the connectors were unintentionally exposed to a gradual buildup by all the preliminary tests that were performed on them. Leakage was read continuously during the performance of this test; the maximum value is entered in Table 2 for Test j.

Preliminary tests were performed on connector F116 so that a reading of stress at position 1 could be used to determine stress at position 2. A strain gage was mounted at position 2 on this connector and at position 1. The gage at position 1 was calibrated against the calculated stress produced by a known load exerted on the connector in the vertical direction. It was calculated that the weight at center span should produce a stress of 2007 psi at position 1; when reliance was placed only on manufacturer's data for the strain gage at position 1 a reading of 2030 psi was obtained. Such close agreement generated confidence in the strain gage readings as obtained by manu-

Table 3

SCHEDULE OF STRESS AND CYCLES FOR HIGH-TEMPERATURE AND VIBRATION TESTS

Connector	Order of Testing	Temperature (°F)	Bending Stress (psi)	Number of Cycles
F114	second	700	21,600	10^6
		700	24,000	10^6
F116	first	70	2,400	0.16×10^6
		70	3,600	0.16×10^6
		70	4,800	0.16×10^6
		70	6,000	0.16×10^6
		700	9,600	10^6
		700	14,400	10^6
		700	16,800	10^6
		700	19,200	10^6
		700	21,600	10^6
		700	24,000	10^6
F117	fourth	700	21,600	0.66×10^6*
F127	third	700	21,600	0.32×10^6*
F128	sixth	700	6,000	0.16×10^6
		700	12,000	0.16×10^6
		700	18,000	0.16×10^6
		700	19,200	10^6
		700	21,600	10^6
		700	24,000	10^6
F129	fifth	700	21,600	0.16×10^6*
F131	seventh	700	6,000	0.16×10^6
		700	12,000	0.16×10^6
		700	18,000	0.16×10^6
		700	19,200	10^6
		700	21,600	10^6
		700	24,000	10^6

*Failure of weld at tube and conical end cap.

facturer's data alone. This conclusion was extrapolated to the strain gage mounted at position 2 (note that it is difficult to calculate the stress produced at position 2 because of the flare and irregular shape of the tube in that region). Connector F116 was then vibrated in a configuration exactly like that to be used in the vibration test; the bellows, pressure supply tube, and vacuum tube were all in place. Simultaneous stress readings were taken from position 1 and position 2. From them the following relationship was obtained between dynamic bending stresses at position 1 and position 2:

$$\sigma_2 = 1.2\,\sigma_1$$

It was then possible to run all the connector vibration tests and estimate stress at the interface of the tube and the sleeve by measuring stress at the outside of the bellows at position 1.

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Section 5

DEVELOPMENT HISTORY

For the sake of brevity and conciseness, Sections 1 through 4 have been concerned only with the end result of the X-connector Feasibility Studies: what the X-connector looks like and how it is assembled, the investigators' opinion of it, and the tests through which that opinion was arrived at. However, a great deal of effort was put into selective studies and subsidiary studies which have not yet been discussed. An explanation of this work will present a more complete picture of the project.

SELECTION OF BASIC CONFIGURATION

The first task in this development was the selection of a basic configuration for the connector. Figure 15 shows early drawings of the three design options available. Design 1, which, by a process of elimination, was selected early in the program as the superior design of the three, does not necessarily look like the design shown in previous sections; these drawings serve only to illustrate the differences between the connector variations that were considered.

Design 2 was eliminated because it required that the seal be formed against the flared tube. This means that one of the sealing surfaces must be manufactured in the field. Design 2 also requires a different sleeve and seal design for every tube thickness for which an X-connector is to be available, while design 1 requires only a new sleeve design for every tube thickness. The principal reason for even considering design 2 is that it had one intriguing advantage: there is no leak path through the tube-sleeve swage, as there is in designs 1 and 3. This was not enough, however, to outweigh its disadvantages and the design was discarded.

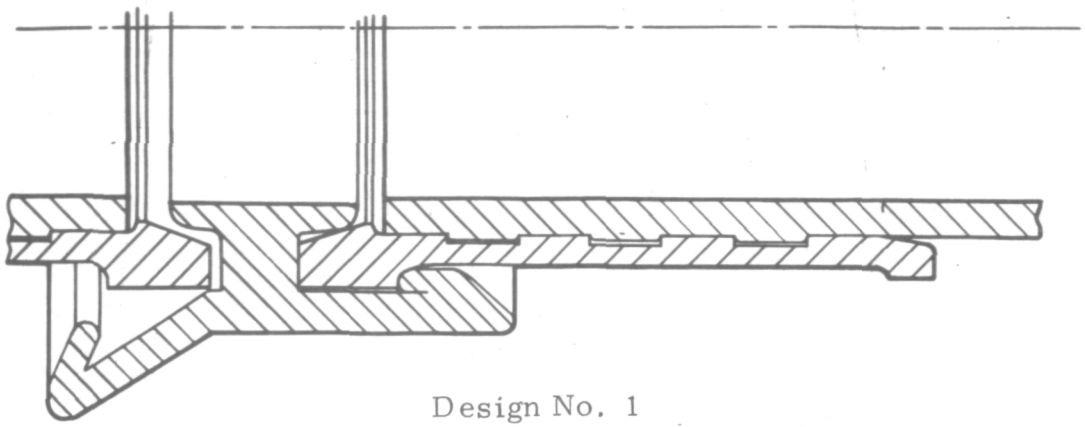
Design 3 was discarded because it was not truly semipermanent but permanent. The seal surface, which is integral with the sleeve, proved not to be reusable; thus the connector is not semipermanent. This design also has one of the same disadvantages that design 1 has -- the fact that the tube-sleeve swage is a leak path. The design was discarded as inferior to design 1.

The decision to commit the program to the development of design 1 was not based merely on opinion but on tests of the seals, collar, and sleeves involved.

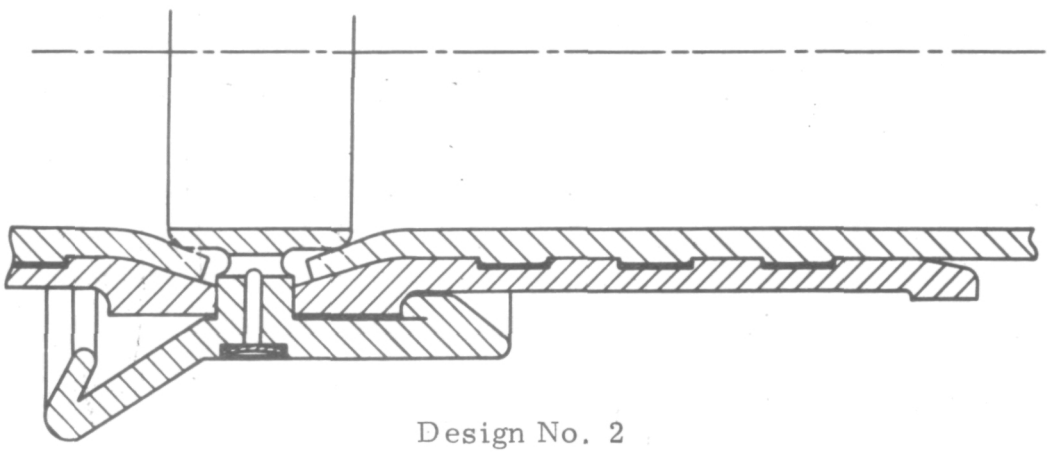
Initial Seal Studies

Tests were performed as follows on simulated seals for design 1:

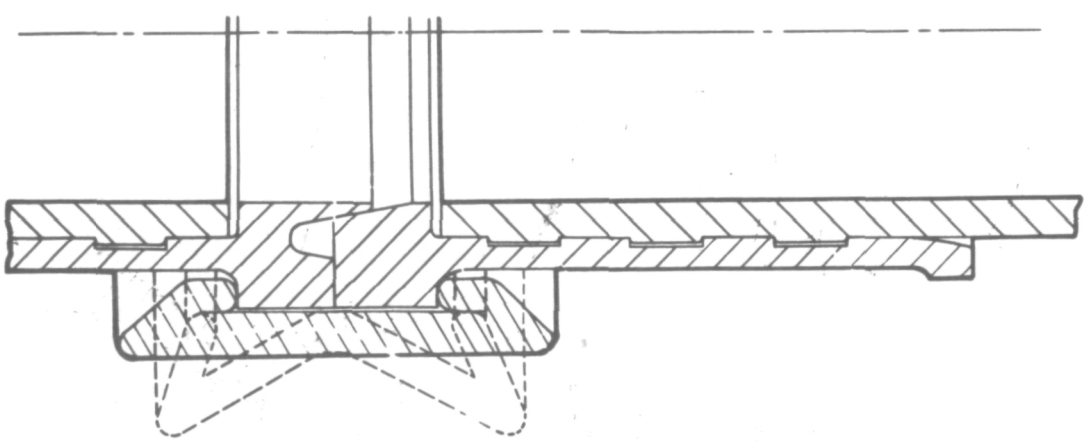
- Test J - Four engagements of male and female Inconel 718 surfaces were made. All male surfaces involved in this test were gold-plated and all female surfaces unplated. Engagement lengths, or strokes,



Design No. 1



Design No. 2



Design No. 3

Figure 15. Design Configurations Considered

were 0.0200, 0.0190, 0.0215, and 0.0020 inch. Engagement length or stroke is defined as the relative axial movement between the male and female surfaces after initial contact has been made. Leakage was measured as each engagement progressed from zero to its full value so that the engagement necessary to establish a seal would be known. A new male surface was used at each engagement, consistent with the intended field practice for design 1.

- Test Ja - Four engagements, exactly as above but with engagement lengths of 0.0200, 0.0210, 0.0200, and 0.0195 inch.

In all these tests the seal was satisfactorily established at engagement strokes of 0.0050 inch or less (a "seal" is defined as leakage less than 10^{-6} atm-cc/sec). The tests showed that design 1 was feasible. Indeed, this seal was never a major problem area throughout the entire program.

Tests were performed on simulated seals for design 2:

- Test L - Four engagements of male and female surfaces were made. The male surface was gold plated Inconel 718 and the female surface was unplated 303 CRES in all tests. Engagement lengths were 0.0540, 0.0560, 0.0570, and 0.0290 inch. A new male surface was used at each engagement, consistent with field practice for design 2.
- Test Q - Four engagements similar to Test J were made, but the female surface was burnished in an attempt to have it more closely simulate the flared tube which is used as a sealing surface in design 2. Engagement strokes were 0.0200, 0.0200, 0.0200, and 0.0200 inch.

As a result of these tests, design 2 appeared questionable. Test L showed erratic performance. For instance, on the third engagement, a seal was established at 0.0050-inch engagement but upon further engagement to 0.0570 inch it developed a leak. Test Q consistently showed seals at 0.0050-inch engagement or less, but there was doubt as to whether the burnished female surface truly simulated a flared tube.

Tests were performed as follows on the simulated seals for design 3:

- Test A - Two engagements of unplated Inconel 718 male and female surfaces were made. The same male and female surfaces were used for each engagement consistent with one possible way of using this design in the field. In both cases, the engagement stroke was 0.0045 inch.
- Test B - This test was the same as Test A, except that a new female surface was used on the second engagement. This is consistent with another possible manner of using design 3 in the field.

Test P - In this test there were six engagements of gold-plated Inconel 718 male and female surfaces. The engagement strokes were 0.0070, 0.0060, 0.0115, 0.0100, 0.0100, and 0.0105 inch. The same male and female surfaces were used for each engagement.

Test Pa - There were six engagements of gold-plated Inconel 718 male and female surfaces in this test. The engagement strokes were 0.0065, 0.0075, 0.0100, 0.0100, 0.0100, and 0.0100 inch. A new female surface was used for each engagement.

The results of these tests indicated that design 3 was not feasible. Leakage was always greater than 10^{-6} atm-cc/sec in Tests A and B. It was better in Tests P and Pa, with the gold plating, but still erratic. For example, in Test Pa a seal was established at engagements 1 and 3 but could not be established at engagement 2.

Initial Collar Studies

The requirement of the collar and its swaging are common to all three designs shown in Figure 15. It follows, then, that the collar performance did not contribute to the selection of one of the three designs. It was necessary, however, to show that the collar swage could be performed satisfactorily before any of the designs could be considered feasible. For this reason, the initial collar studies are discussed here.

Collar swaging experiments were performed using a toggle-action tool (Ref. 6). In the cross-section of the first swaged collar shown in Figure 16 the lips of the collar are seen to rest on the outer conical portion of the sleeve rather than on the sleeve flange. The mock-up assembly shown in the figure was tested for leakage before sectioning. The leak test was performed by pressurizing to 5,950 psi with nitrogen and examining for bubbles while the mock-up was submerged under water. No bubbles appeared.

Modified collars were then constructed and subjected to tests wherein their deformations were observed. The swaging action of the collar did not appear to be ideal.

From these preliminary tests it was concluded that the hourglass (or "X") shaped collar was feasible, but not yet performing as required. Since the performance of the collar and the collar swaging tool are intrinsically linked together, it was concluded that any further studies of this part should jointly treat both the tool and the collar. Accordingly, a study program for collar-swaging tool improvement (Ref. 6) was authorized. That study will be discussed in this section.

Initial Tube Swaging Studies

If either design 1 or design 3 from Figure 15 were to be feasible, it was necessary to show that the tube-sleeve swage could be made leakproof. It

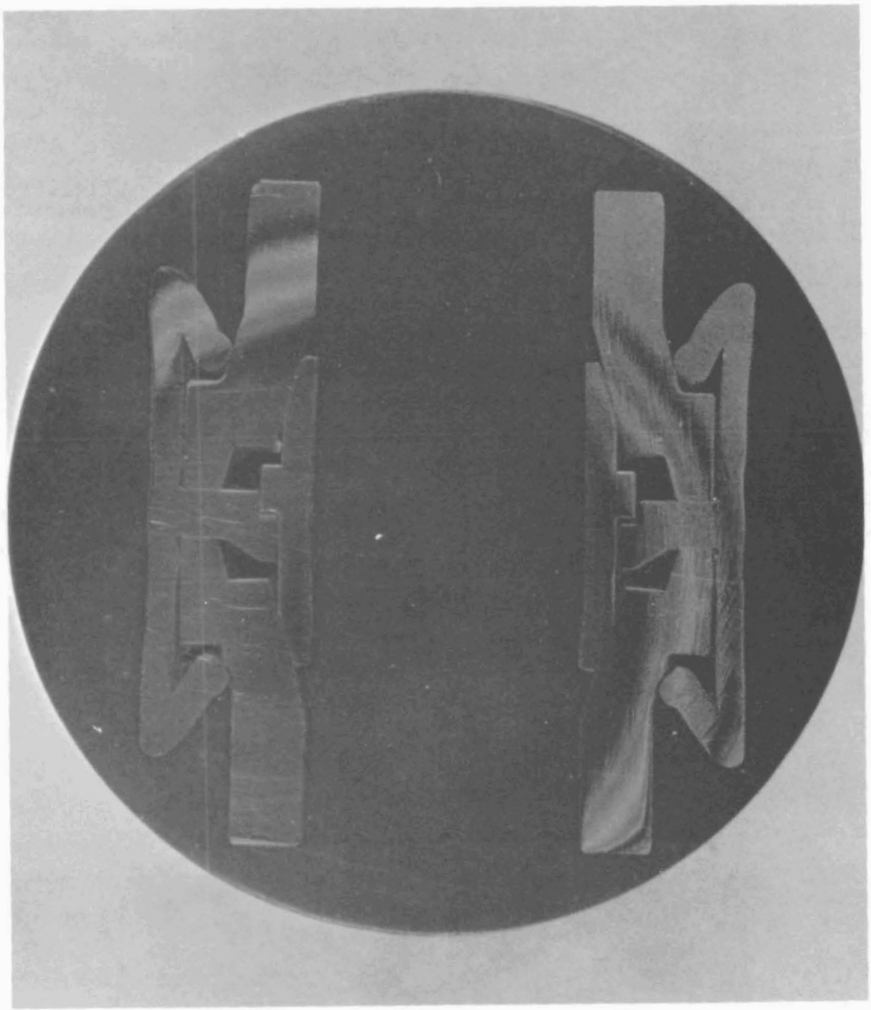


Figure 16. Section of First Swage Collar

was also necessary to show that the tube-sleeve swage could be made structurally sound if any of the designs in Figure 15 were to be feasible. Accordingly, tube-sleeve assemblies were subject to tests for:

- Tensile strength
- Vibration endurance
- Heat-soak endurance

One important parameter under consideration in these tests was the number of contact rings necessary to make a successful swage. The number of contacts affects the length of the sleeve and therefore affects the total weight of the connector. Another parameter that was varied in these tests was the sharpness of the corners of the contact rings.

Tensile tests were performed on tube-sleeve assemblies. One each of sleeves with one contact ring, three contact rings, five sharp contact rings, five rounded contact rings, and 10 contact rings were used in these tube-sleeve assemblies. The tests were performed to determine the strength of the swage relative to the tubing itself. The appearance after the pull test indicated that the strength of the swage exceeded the yield strength of 321 CRES tubing with 0.049-inch wall and half-inch diameter. In each case, except for the single-contact sleeve, the tubing necked down to a definite yield without any detrimental slippage in the swaged areas. (Figures 17 and 18)

Vibration studies were performed on single-contact sleeves. Two sleeves with single contacts (Figure 17) were clamped together with a simulated collar and vibrated. The vibration stress level was measured on the tube near the end of the sleeve. The assembly was vibrated for 10^8 cycles at 5000-psi stress, after which it was checked for leakage by internal pressurization with helium at 3000 psi. It was then vibrated for 10^8 cycles at 10,000-psi tube stress. Leakage after both tests was less than 10^{-8} atm-cc/sec, as measured by a mass spectrometer.

Vibration and heat-soak tests were also performed. They were executed on pairs of five-contact sleeves clamped together with a simulated collar. The sleeves used in making the tube-sleeve assembly had rounded corners or sharp corners. The sharp corners had a 0.003-inch radius and the rounded corners had a 0.007-inch radius. The sequence of tests is shown in Figure 19. Prior to the start of the heat-soak tests, it was decided that the sharp- and round-cornered sleeves should each be exposed to both tests. That is the reason for the indicated swap of tube-sleeve assemblies 13A and 15A in Figure 19. All leak tests indicated less than 10^{-6} atm-cc/sec unless otherwise stated.

These tests indicated that it was feasible to obtain a tube-sleeve swage for any of the designs in Figure 15. They also indicated that more than one and fewer than 10 contact rings were required. Vibration resistance and performance at high temperatures appeared to be satisfactory.

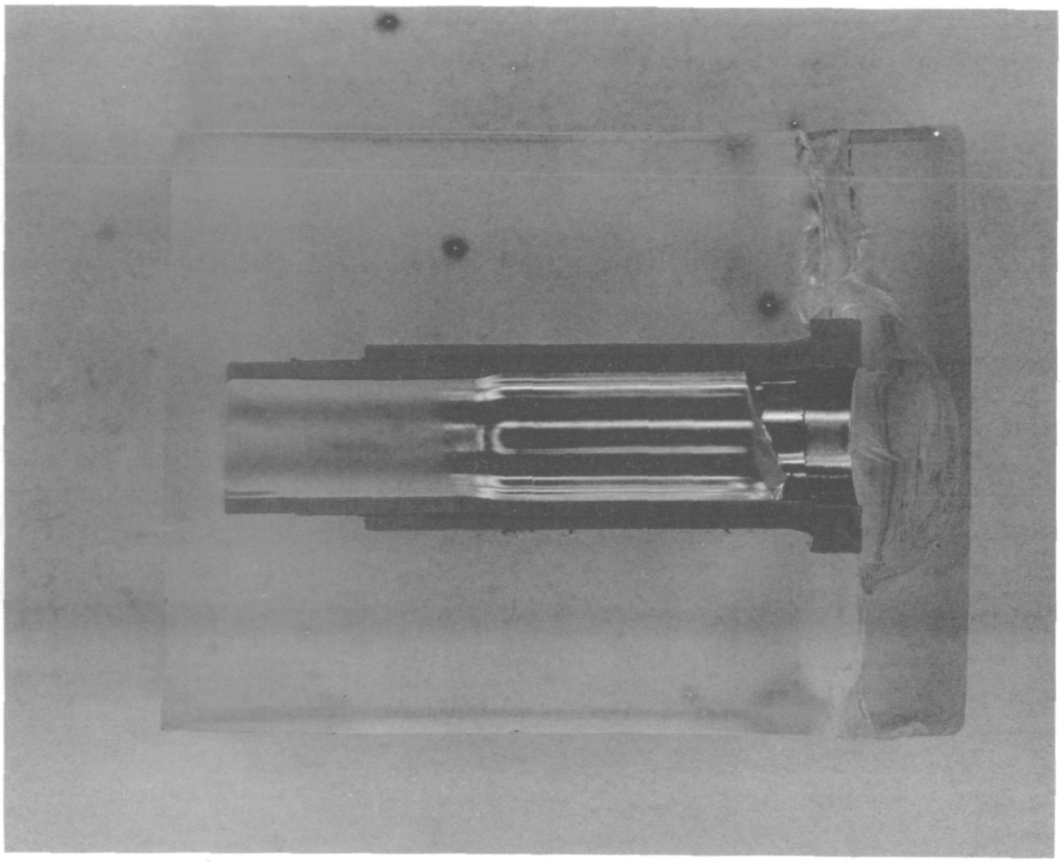


Figure 17. Section of Single-contact Sleeve after Tensile Test

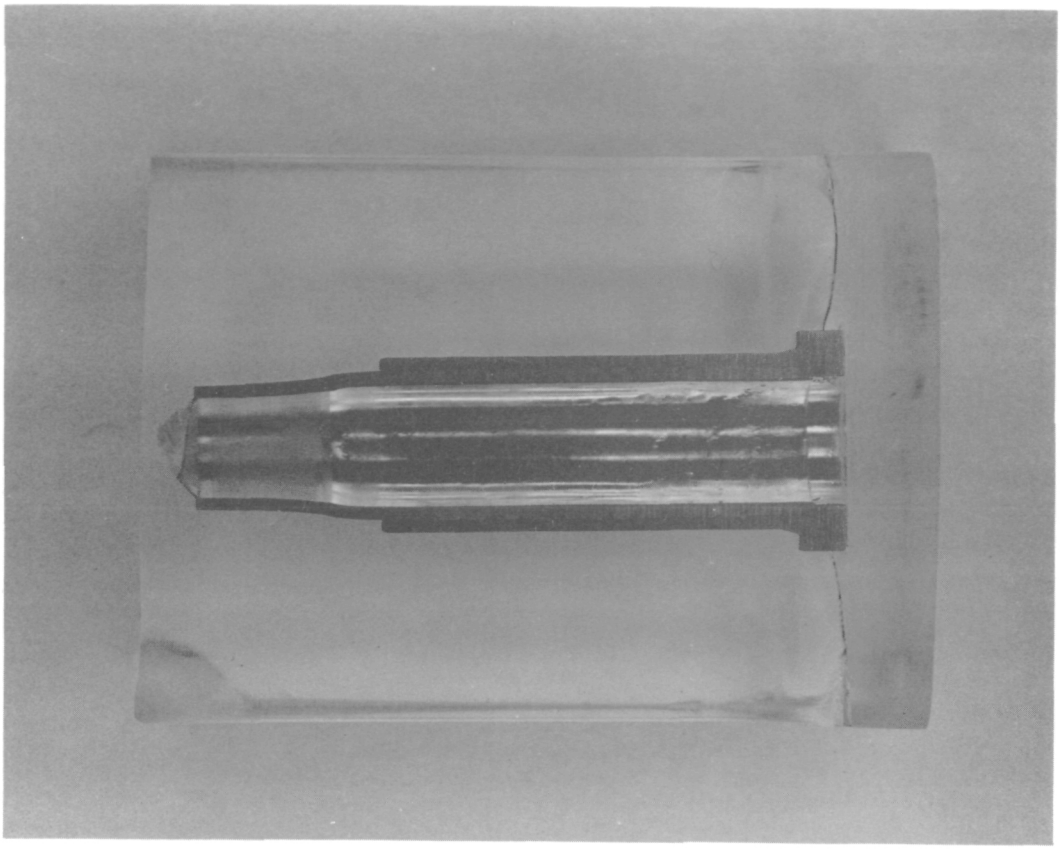
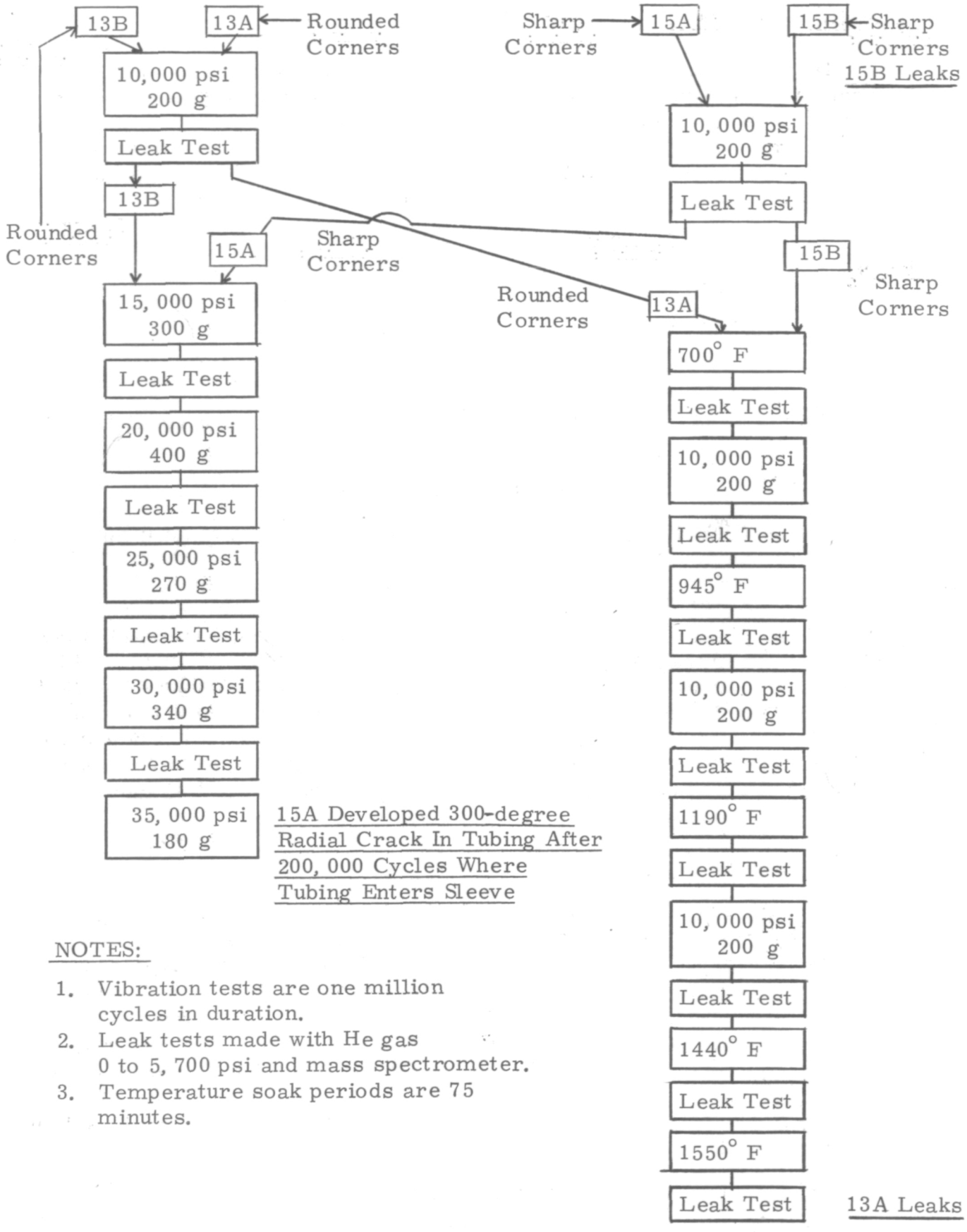


Figure 18. Section of Ten-contact Sleeve after Tensile Test



NOTES:

1. Vibration tests are one million cycles in duration.
2. Leak tests made with He gas 0 to 5, 700 psi and mass spectrometer.
3. Temperature soak periods are 75 minutes.

Figure 19. Vibration and Heat-soak Tests

COLLAR SWAGING TOOL IMPROVEMENT STUDY

During the initial connector component studies, it became obvious that alternative designs for the collar swaging tool should be studied. All the swages in the initial studies were made with a toggle-action tool which can be seen in Reference 6. There were, however, other, untried concepts under consideration at that time. A formal study program was initiated on the following methods for collar swaging:

- Toggle swaging
- Roll swaging
- Draw swaging
- Radial swaging

Toggle swaging had, of course, been tried and the following disadvantages noted:

- The collar shell elongates during forming.
- The tool diameter would be large even for tools designed for field use.
- Only one side of the collar can be swaged at a time.

Roll swaging was eliminated without trial because the reactive torque would disturb the collar during the swage, making it either complicated or difficult to use. Draw swaging was likewise eliminated without trial because it involved a wiping action of the collar, with the result that the tool or collar or both would be galled. The radial swaging tool shown in Figures 6 and 7 was built and tested. It swaged satisfactorily without the inherent disadvantages of the toggle tool. Recommendation for the use of this tool was made and accepted.

TUBE SWAGING TOOL

All tube swages in the initial component studies and in the 3000-psi feasibility tests were carried out with a roller swaging tool. It is shown in operation in Figure 20. The tool is clamped in the lathe tailstock, the tube is clamped in the lathe collet, and the sleeve rests on the tube. The rollers (two of which can be seen in Figure 20) are tapered, with their large ends furthest into the tube. They are captured in a cage. In operation, the tubing is rotated, the rollers are placed full-depth into the tubing, and the tailstock is moved slowly toward the tube. The motion of the tailstock drives a tapered mandrel under the rollers, forcing them out in the radial direction and swaging the tube to the sleeve.

This tool has two major disadvantages:

- The concentrated forces of the roller swaging tool do not achieve the same favorable residual stress as does the tool shown in

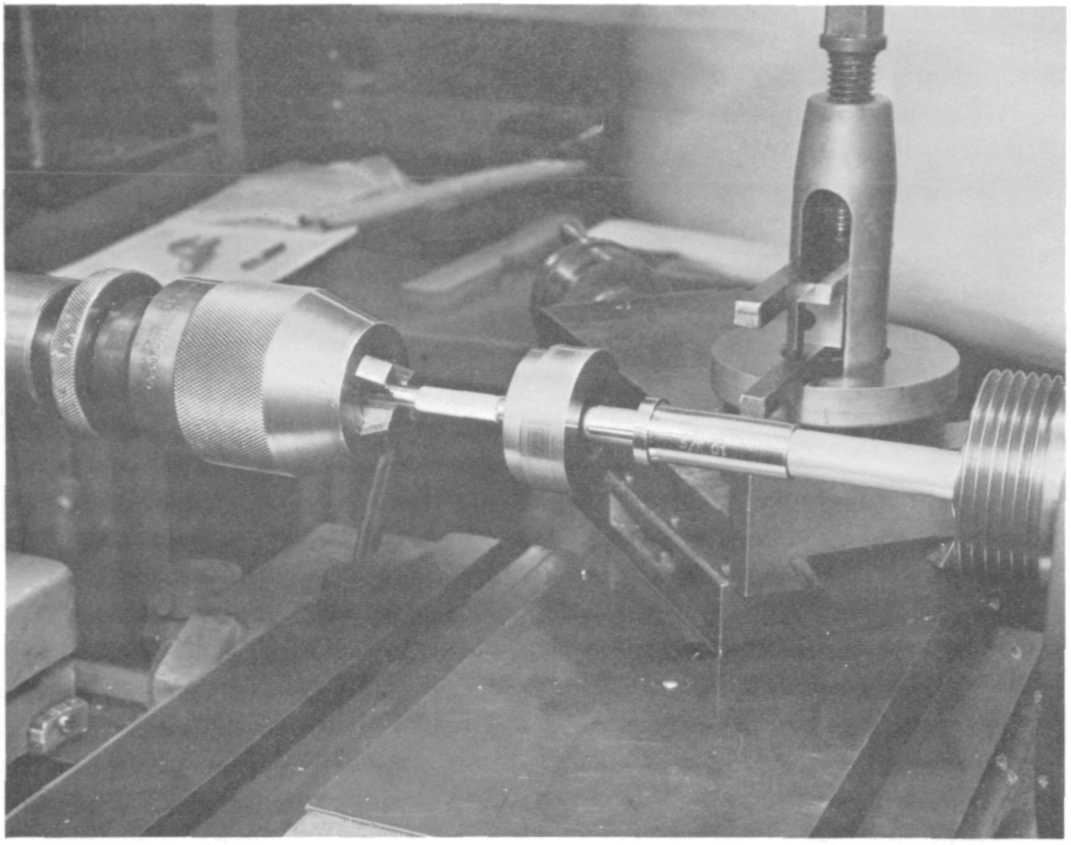


Figure 20. The Roller Swaging Tool

Figure 4. The resulting mechanical joint of the tube and the sleeve is not as leak tight with roller swaging.

- Roller swaging was observed to gall the inside surface of condition B tubing.

To overcome these difficulties, the tool shown in Figure 4 was developed and tested. It had none of these disadvantages and proved superior in its action, although it required some trial and error in the design of its parts before they were structurally satisfactory. It was used exclusively in the final work on 4500-psi connectors.

HALF-INCH, 3000-PSI FEASIBILITY TESTS

In the selection of the basic configuration and the performance of tool studies, all individual pieces were shown feasible by themselves. Refinements had even been added, but no full connectors had as yet been shown feasible. Approximately 15 months after the start of the program, it was shown that a half-inch,3000-psi connector was feasible for production. The commitment to feasibility demonstration of a 3000-psi connector was made prior to the establishment of the requirement for a 4500-psi connector.

Feasibility of the half-inch,3000-psi connector was demonstrated by testing three full connector assemblies. The sleeves of these connectors had five contact rings and the tubing was 304 CRES condition A, with wall thickness of 0.049 inch. All connectors were assembled with the roller swaging tool. One connector was subject to vibration tests with bending stress of 10,000 psi, 20,000 psi, and 25,000 psi for 10^6 cycles at each stress. The stress was measured in the tube adjacent to the sleeve. Leakage was measured at proof pressure (6000 psi) after each test. No leak was measured until after the 25,000-psi test, when the collar cracked in three places. The connector endurance stress of 20,000 to 25,000 psi was surprising in light of the specified strength for this tubing. The yield strength of the tubing was only 30,000 psi.

One connector was subjected to tensile tests. It developed some leakage at 2000 pounds tensile load (1.87×10^{-6} atm-cc/sec). The weld between the tube and tension bar on the testing machine failed at 2075 pounds and the test was aborted. The connector had structural integrity and was judged satisfactory.

Another connector was subjected to impulse testing in accordance with specification MIL-F-18280B, paragraph 4.8.3, except that the number of impulse cycles was reduced to 10,000. No liquid leakage was observed at 6000 psi after impulse testing. The same connector used for impulse testing was then subjected to burst tests. At 15,600-psi internal pressure, the tubing burst, leaving the connector intact. The connector showed no leakage at any time during the tests.

This demonstration of feasibility on the 3000-psi connector was an important intermediate step. It helped to provide the necessary confidence to proceed with the development of the 4500-psi connector.

ESTABLISHING A VIBRATION GOAL

The vibration endurance of the fluid connector is most logically evaluated by comparing the endurance of the tube-connector assembly to the endurance of a plain tube. Specifically, the failure stress and number of cycles in the tubing adjacent to the connector is compared to the failure stress and number of cycles for plain tubing. In order to establish these values for tubes having no connectors, Parker Aircraft Company ran the necessary vibration tests.

The tests were performed on three specimens of 304 tubing, condition B, half-inch diameter, and 0.058-inch wall thickness. Stress was measured with a strain gage calibrated by placing a known load on the tube and calculating the corresponding stress. The tube was vibrated in fully reversed bending. The following results were obtained:

Bending Stress (psi)	Number of Cycles to Failure
59,300	0.202×10^6
54,200	2.14×10^6
48,000	0.207×10^6

These tests indicate that the endurance limit for the tubing was between 40,000 and 55,000 psi of fully reversed bending stress. The 4500-psi connector has satisfactorily performed to a level of 30,000 psi of fully reversed bending stress. If a vibration endurance efficiency were defined as the ratio of endurance limit of the connector assembly divided by the endurance limit of plain tubing, it could be said the X-connector has an efficiency greater than the range of 55 to 75 percent.

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1. Haas, P. G., "Aspects of Zero Leakage Technology," Proceedings of the Conference on the Design of Leak-tight Fluid Connectors, National Aeronautics and Space Administration, George C. Marshall Space Flight Center, Huntsville, Alabama, August 4 and 5, 1965.

2. Bragg, K.R., "The Problem of Stating the Tube Connector Problem," Proceedings, Design of Leak-tight Separable Fluid Connectors Conference, (Vol 1 of 2), Huntsville, Alabama, March 24 and 25, 1964.

3. Smith, R.E.; LeClerc, E.J.; Ray, M.C., Computer Programs for Flanged and Threaded Connector Design, Vol. I of Final Report on Contract NAS 8-4012, September 1967.

4. Bain, J.A., and Laniewski, J.P., "Tube Connector Design Principles and Evaluation," Vol. V of Zero Leakage Design for Ducts and Tube Connections for Deep Space Travel, Final Report on Contract NAS 8-11523, July 1967.

5. Alloy Digest, ARMCO 304, Filing Code SS-55, May 1957.

6. Johnstone, D.T.; Burton, S.; Morse, G; and Sternenberg, J., Collar Swaging Tool Improvement Study Program, Parker Aircraft Company Engineering Report EER-5650024, July 1965.

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APPENDIX I

Appendix I

HALF-INCH, 4500-PSI CONNECTOR DRAWINGS

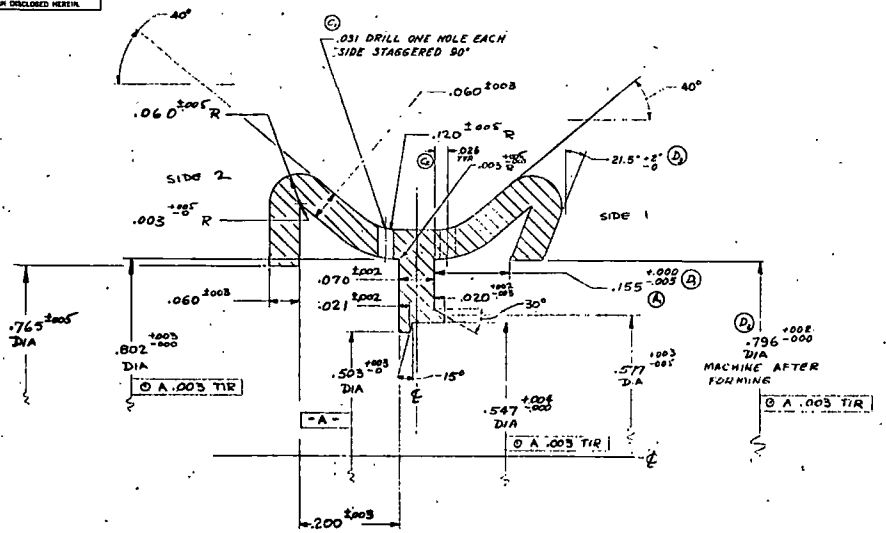
The drawings for the half-inch, 4500-psi connector are listed below. It is important to note the revision in the list because some of the drawings were revised after the completion of this program. Revisions subsequent to those listed below should be ignored.

Part	Parker Aircraft Company Drawing No.	Last Applicable Revision
Sleeve	5659526	G
Collar	5669207	D
Seal	5659539	-
*Tube Swaging Tool	S80-0-265	G
Restraining Collar	5669042	A
Collar Swaging Tool	S80-0-241	D
Leakage Collector	S65-0-1149	-
Leakage Collector	5669058	B

*Some of the parts of the tube swaging tool were used to make a tool which would force sleeve mock-ups onto seals for experimental purposes. In order to do this, some additional parts had to be made; these are shown on sheet 2 of drawing S80-0-265. These parts should not be confused with parts actually used for tube swaging.

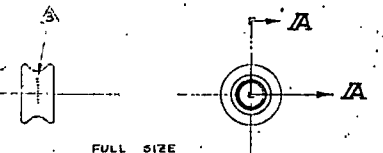
THE PART SHOWN HEREIN IS A PROPRIETARY PRODUCT OF PARKER AIRCRAFT CO. UNLESS NOTED AS CUSTOMER DESIGNED, PARKER RESERVES ALL PATENT AND PROPRIETARY RIGHTS TO THE INFORMATION AND DESIGN DISCLOSED HEREIN.

REVISIONS			
E.C.O. NO.	SYM	DESCRIPTION	DATE
566-1067	—	RELEASED	9/64
566-1332	A	.169 WAS .165	9/64
566-2113	B	RB-0170-038 SPEC. WAS INCO SPEC. CLASS 'B' WAS CLASS 'A'	8-14-64
566-2161	C	ADDED (2) .031 DIA HOLES & DIM. .028	9-15-64
101	D	D_1 WAS .169±.005; D_2 .796 +.005 −.000; D_3 WAS .15"	9/64



HALF SECTION A-A
SCALE ~ 10X

NOTE:- LH LEG DETAIL SHOWS MACHINED DETAIL WHICH IS TYPICAL FOR BOTH SIDES. RH LEG DETAIL SHOWS FORMED & REMACHINED DETAIL TO BE PERFORMED ON BOTH SIDES



ITEM NO.	DWG SIZE	QTY REQD	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL	MATERIAL SPECIFICATION	HEAT TREAT	FINISH	FINISH SPECIFICATION
1				BAR	INCONEL 718	3	2	PASSIVATE	4

LIST OF MATERIAL

(3) MATERIAL SPEC PER ROCKETDYNE RB-0170-038 (B)
(4) PAR. 5.4.2 OF MIL-STD-171 (PASSIVATE)
(3) ELECTRO-CHEM ETCH P/N & S/N HERE
(2) AGE HARDEN @1350°F FOR 10 HRS, FURNACE COOL TO 1200°F FOR A TOTAL TIME OF 18-20 HRS
(1) TRACEABILITY REQ'D PER ES 5-19, CLASS 'B' (A)

NOTES: UNLESS OTHERWISE SPECIFIED

UNLESS OTHERWISE SPECIFIED
DO NOT SCALE DRAWING
DIMENSIONS ARE IN INCHES
TOLERANCES
FRACTIONS DEC ±.005 ANGLES ±0°30'
.X ±.1 .XX ±.02 .XXX ±.010
TOLERANCES OF HOLES SPECIFIED "DRILL" PER ANSI B18.1
MUST CONFORM TO FED-STD-H28 — 1
MACHINED SURFACE 125 PER MIL-STD-29
CLASSIFICATION OF CHARACTERISTICS PER SPI-4235 & MIL-STD-105
REF SI2.4 - C.E.

SIGNATURES — DATE
W. D. BURTON 4-13-66
DRAWN BY
CHK BY
PROJ ENG
APPD BY

Parker Aircraft Co. — LOS ANGELES, CALIFORNIA — DIVISION OF PARKER-HANNIFIN CORP.

TITLE: COLLAR NO. 2-X-FITTING, SIZE 8, 4800 PSI, 700°F, (EDO)

SIZE	CODE IDENT NO.	DWG NO.
D	92003	3669207

SCALE FULL | WEIGHT UNLESS OTHERWISE SPECIFIED 0.061 LBS | SHEET 1 OF 1

NEXT ASSY | USED ON
APPLICATION

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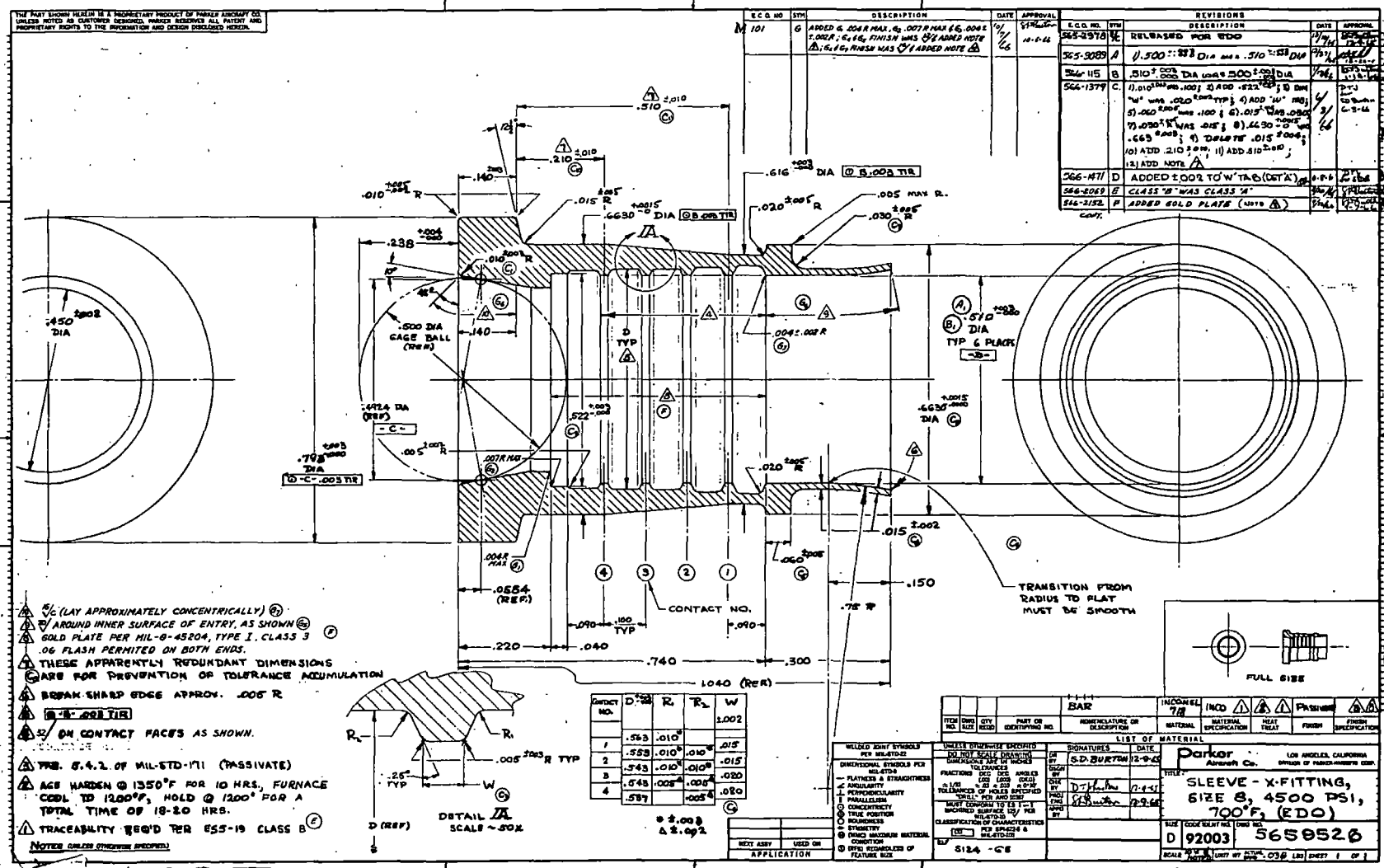

CONTACT NO.	D +.000 -.003	R1	R2	W ±.002
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2	.553	.010	.010	.015
3	.543	.010	.010	.020
4	.543	.008	.008	.020
	.587		.005	

Ⓒ ± .003 Δ ± .002

ECO NO	SYM	DESCRIPTION	DATE	APPROVAL
M 101	G	ADDED Ⓖ .004 R MAX, Ⓖ .007 R MAX & Ⓖ .004 ± .002 R; Ⓖ, Ⓖ, FINISH WAS Ⓖ ADDED NOTE Ⓐ; Ⓖ, Ⓖ, FINISH WAS Ⓖ ADDED NOTE Ⓐ	10/1/66	

REVISIONS				
ECO NO.	SYM	DESCRIPTION	DATE	APPROVAL
565-2978	K	RELEASED FOR EDO	11/9/64	
565-3089	A	(1) .500 +.003 -.000 DIA and .510 +.003 -.000 DIA	12/3/64	
566-115	B	.510 +.003 -.000 DIA and .500 +.002 -.003 DIA	1/26/65	
566-1379	C	(1) .010 +.005 -.002 MIN .001; 2) ADD .822 +.002 -.003; 3) DIM "W" WAS .020 +.002 -.003 TYP; 4) ADD "W" MIN; 5) .060 ±.005 WAS .100; 6) .015 +.005 -.000 WAS .080; 7) .030 +.005 -.000 R WAS .015; 8) .4430 +.0015 -.0000 WAS .665 +.003 -.000; 9) DELETE .015 +.004 -.002; 10) ADD .210 ±.010; 11) ADD .510 +.010 -.000; 12) ADD NOTE Ⓐ	4/3/66	
566-1471	D	ADDED ±.002 TO 'W' TAG (DET 'A')	6-17-66	
566-2069	E	CLASS "B" WAS CLASS "A"	9-2-66	
566-3152	P	ADDED GOLD PLATE (NOTE Ⓐ)	9-14-66	

CONT.

Ⓐ .5/C (LAY APPROXIMATELY CONCENTRICALLY) Ⓖ
Ⓐ .5/ AROUND INNER SURFACE OF ENTRY, AS SHOWN Ⓖ
Ⓐ GOLD PLATE PER MIL-G-45204, TYPE I, CLASS 3 Ⓕ
.06 FLASH PERMITED ON BOTH ENDS.
Ⓐ THESE APPARENTLY REDUNDANT DIMENSIONS Ⓖ ARE FOR PREVENTION OF TOLERANCE ACCUMULATION
Ⓐ BREAK SHARP EDGE APPROX. .005 R
Ⓐ Ⓒ B .003 TIR
Ⓐ 32/ ON CONTACT FACES AS SHOWN.
Ⓐ TREB. 6.4.2. OF MIL-STD-1711 (PASSIVATE)
Ⓐ AGE HARDEN @ 1350°F FOR 10 HRS., FURNACE COOL TO 1200°F, HOLD @ 1200° FOR A TOTAL TIME OF 18-20 HRS.
Ⓐ TRACEABILITY REQ'D PER ESS-19 CLASS B Ⓕ

NOTES: UNLESS OTHERWISE SPECIFIED

ITEM NO.	DWG SIZE	QTY REQD	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL	MATERIAL SPECIFICATION	HEAT TREAT	FINISH	FINISH SPECIFICATION
				BAR	INCONEL 718	INCO Ⓐ Ⓐ Ⓐ		PASSIVATE	Ⓐ Ⓐ

LIST OF MATERIAL

NEXT ASSY | USED ON
APPLICATION

WELDED JOINT SYMBOLS PER MIL-STD-22

DIMENSIONAL SYMBOLS PER MIL-STD-9
— FLATNESS & STRAIGHTNESS
⊿ ANGULARITY
⊥ PERPENDICULARITY
// PARALLELISM
○ CONCENTRICITY
⊕ TRUE POSITION
○ ROUNDNESS
= SYMMETRY
Ⓜ (MMC) MAXIMUM MATERIAL CONDITION
Ⓢ (RFS) REGARDLESS OF FEATURE SIZE

UNLESS OTHERWISE SPECIFIED
DO NOT SCALE DRAWING
DIMENSIONS ARE IN INCHES
TOLERANCES
FRACTIONS .XX ± .03 ANGLES ±1°
.XXX ± .010 .XXXX ± .0050
TOLERANCES OF HOLES SPECIFIED TO ALL .XXX AND DEEP
MUST CONFORM TO ES 1—1
MACHINED SURFACE 125/ PER MIL-STD-10
CLASSIFICATION OF CHARACTERISTICS
125 PER SPEC 4 & MIL-STD-100
EJ 5124 -GE

SIGNATURES	DATE
DR BY S.D. BURTON	12-9-65
DESGN BY	
CHK BY D.T. [illegible]	1-4-65
PROJ ENG [illegible]	12-9-66
APVD BY	

Parker Aircraft Co. LOS ANGELES, CALIFORNIA DIVISION OF PARKER-HANNIFIN CORP.

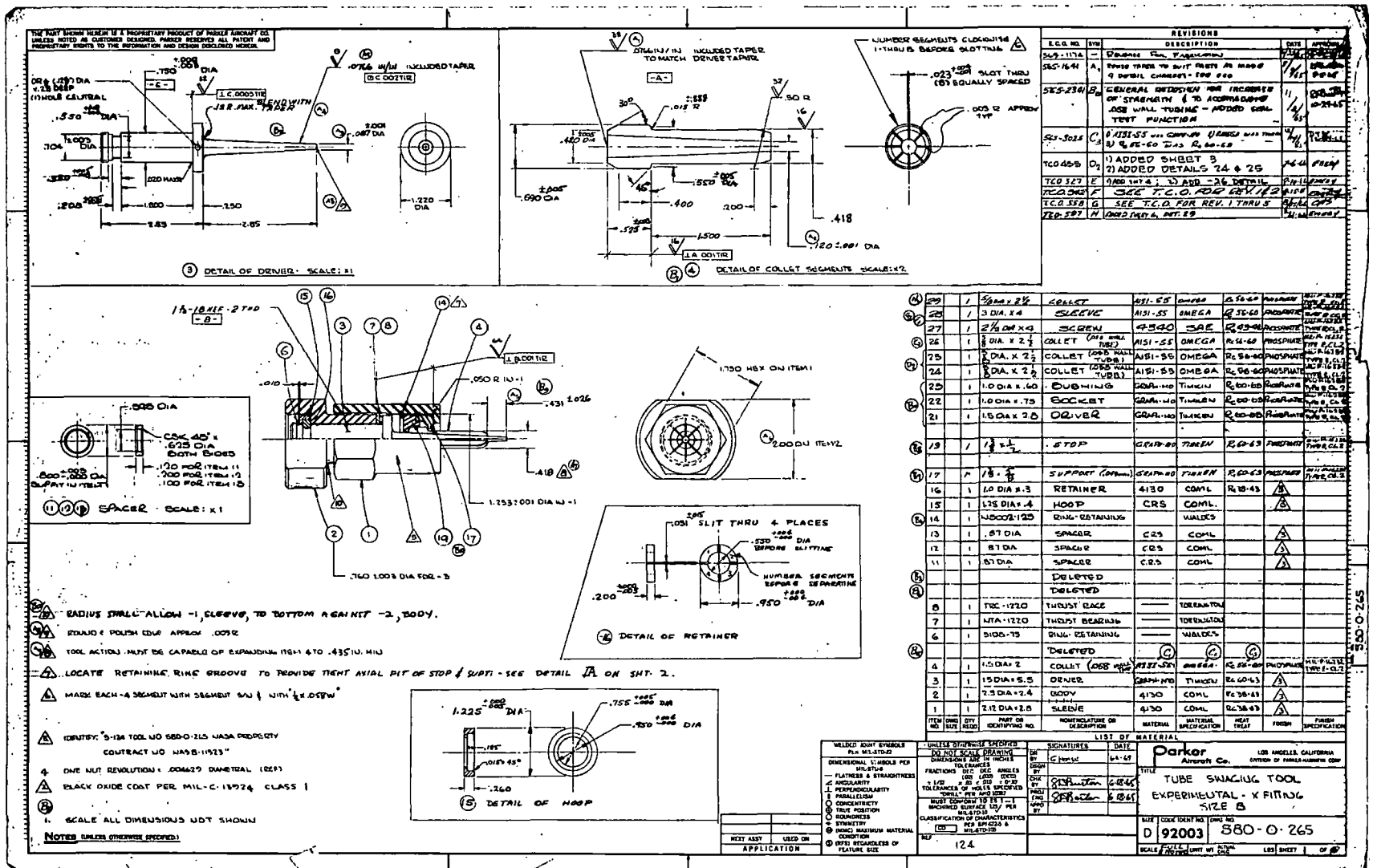
TITLE: SLEEVE - X-FITTING, SIZE 8, 4500 PSI, 700°F, (EDO)

SIZE	CODE IDENT NO.	DWG NO.
D	92003	5659526

SCALE 10 0 5 10 FULL SIZE | UNIT WT NET/GRS .038 LBS | SHEET 1 OF 1

FULL SIZE

5659526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DETAIL OF DRIVER - SCALE: 1:1
DETAIL OF COLLET SEGMENTS SCALE: 1:2
SPACER - SCALE: 1:1
DETAIL OF RETAINER
DETAIL OF HOOP
NOTES (UNLESS OTHERWISE SPECIFIED)
1. SCALE ALL DIMENSIONS NOT SHOWN
IDENTIFY: "S-134 TOOL NO 580-0-215 NASA PROPERTY CONTRACT NO NAS8-11523"
ONE NUT REVOLUTION = .004629 DIAMETRAL (REF)
BLACK OXIDE COAT PER MIL-C-13924 CLASS 1
LOCATE RETAINING RING GROOVE TO PROVIDE TIGHT AXIAL FIT OF STOP & SUPT - SEE DETAIL A ON SHT. 2.
MARK EACH -4 SEGMENT WITH SEGMENT NO. 1 WITH 1/4 DSTW
RADIUS SMALL - ALLOW -1, SLEEVE, TO BOTTOM AGAINST -2, BODY.
ROUND & POLISH EDGE APPROX .005R
TOOL ACTION - MUST BE CAPABLE OF EXPANDING ITEM 1 4 TO .435 I.D. MIN
REVISIONS
ECO NO. SYM DESCRIPTION DATE APPROVED
549-1174 – RELEASE FOR FABRICATION
585-1641 A1 TAPER TRIED TO SUIT PARTS AS MADE & DRILL CHANGED - TOO BIG
585-2341 B1 GENERAL REVISION FOR INCREASE OF STRENGTH & TO ACCOMMODATE .058 WALL TUBING - MODIFY COIL TEST FUNCTION
585-3025 C1 1) ITEMS 55 WAS CHANGED TO MEET 2) ADDED DETAILS 24 & 25
TCO 455 D1 1) ADDED SHEET 3 2) ADDED DETAILS 24 & 25
TCO 527 E 1) ADD SHT 4; 2) ADD -26 DETAIL
TCO 562 F SEE T.C.O. FOR REV. 1 THRU 5
TCO 558 G SEE T.C.O. FOR REV. 1 THRU 5
TCO 597 H (ADD SHEET 4, DET. E)
LIST OF MATERIAL
ITEM NO. DWG SIZE QTY REQD PART OR IDENTIFYING NO. NOMENCLATURE OR DESCRIPTION MATERIAL MATERIAL SPECIFICATION HEAT TREAT FINISH FINISH SPECIFICATION
29 1 5/8 DIA x 2 1/2 COLLET AISI-55 OMEGA R 56-60 PHOSPHATE
28 1 3 DIA. X 4 SLEEVE AISI-55 OMEGA R 56-60 PHOSPHATE
27 1 2 7/8 DIA x 4 SCREW 4340 SAE R 39-45 PHOSPHATE
26 1 1/2 DIA. X 2 1/2 COLLET (.058 WALL TUBE) AISI-55 OMEGA R 56-60 PHOSPHATE
25 1 1/2 DIA. X 2 1/2 COLLET (.035 WALL TUBE) AISI-55 OMEGA R 56-60 PHOSPHATE
24 1 1/2 DIA. X 2 1/2 COLLET (.028 WALL TUBE) AISI-55 OMEGA R 56-60 PHOSPHATE
23 1 1.0 DIA x .60 BUSHING GRAPHITE TIMKEN R 60-65 PHOSPHATE
22 1 1.0 DIA x .75 SOCKET GRAPHITE TIMKEN R 60-65 PHOSPHATE
21 1 1.5 DIA x 2.5 DRIVER GRAPHITE TIMKEN R 60-65 PHOSPHATE
19 1 1 3/4 x 1 1/2 STOP GRAPHITE TIMKEN R 60-63 PHOSPHATE
17 1 1 1/8 - 12 SUPPORT (OPTIONAL) GRAPHITE TIMKEN R 60-63 PHOSPHATE
16 1 1.0 DIA x .3 RETAINER 4130 COML R 38-43
15 1 1.25 DIA x .4 HOOP CRS COML
14 1 N5002-125 RING-RETAINING WALDES
13 1 .87 DIA SPACER C23 COML
12 1 .87 DIA SPACER C23 COML
11 1 .87 DIA SPACER C23 COML
DELETED
DELETED
8 1 TRC-1220 THRUST RACE ——— TORRINGTON
7 1 NTA-1220 THRUST BEARING ——— TORRINGTON
6 1 5100-75 RING-RETAINING ——— WALDES
DELETED
4 1 1.5 DIA x 2 COLLET (.058 WALL TUBE) AISI-55 OMEGA R 56-60 PHOSPHATE
3 1 1.5 DIA x 5.5 DRIVER GRAPHITE TIMKEN R 60-63
2 1 2.5 DIA x 2.4 BODY 4130 COML R 38-43
1 1 2.12 DIA x 2.8 SLEEVE 4130 COML R 38-43
WELDED JOINT SYMBOLS PER MIL-STD-22
DIMENSIONAL SYMBOLS PER MIL-STD-8
UNLESS OTHERWISE SPECIFIED DO NOT SCALE DRAWING DIMENSIONS ARE IN INCHES
TOLERANCES FRACTIONS DEC ANGLES
± 1/32 ± .01 ± 0°30
TOLERANCES OF HOLES SPECIFIED "DRILL" PER ANSI B 18.2
MUST CONFORM TO 125 MACHINED SURFACE REQ PER MIL-STD-10
CLASSIFICATION OF CHARACTERISTICS PER MIL-STD-1
CRITICAL
MAJOR
MINOR
REF 124
SIGNATURES DATE
DR BY C Hewitt 6-4-65
DESIGN BY
CHK BY 6-8-65
PROJ ENG 6-8-65
APPD BY
NEXT ASSY USED ON
APPLICATION
Parker Aircraft Co. LOS ANGELES, CALIFORNIA DIVISION OF PARKER-HANNIFIN CORP
TITLE TUBE SWAGING TOOL EXPERIMENTAL - X FITTING SIZE 8
SIZE D CODE IDENT NO. 92003 DWG NO. 580-0-265
SCALE FULL UNIT WT ACTUAL CALC LBS SHEET 1 OF 4
580-0-265

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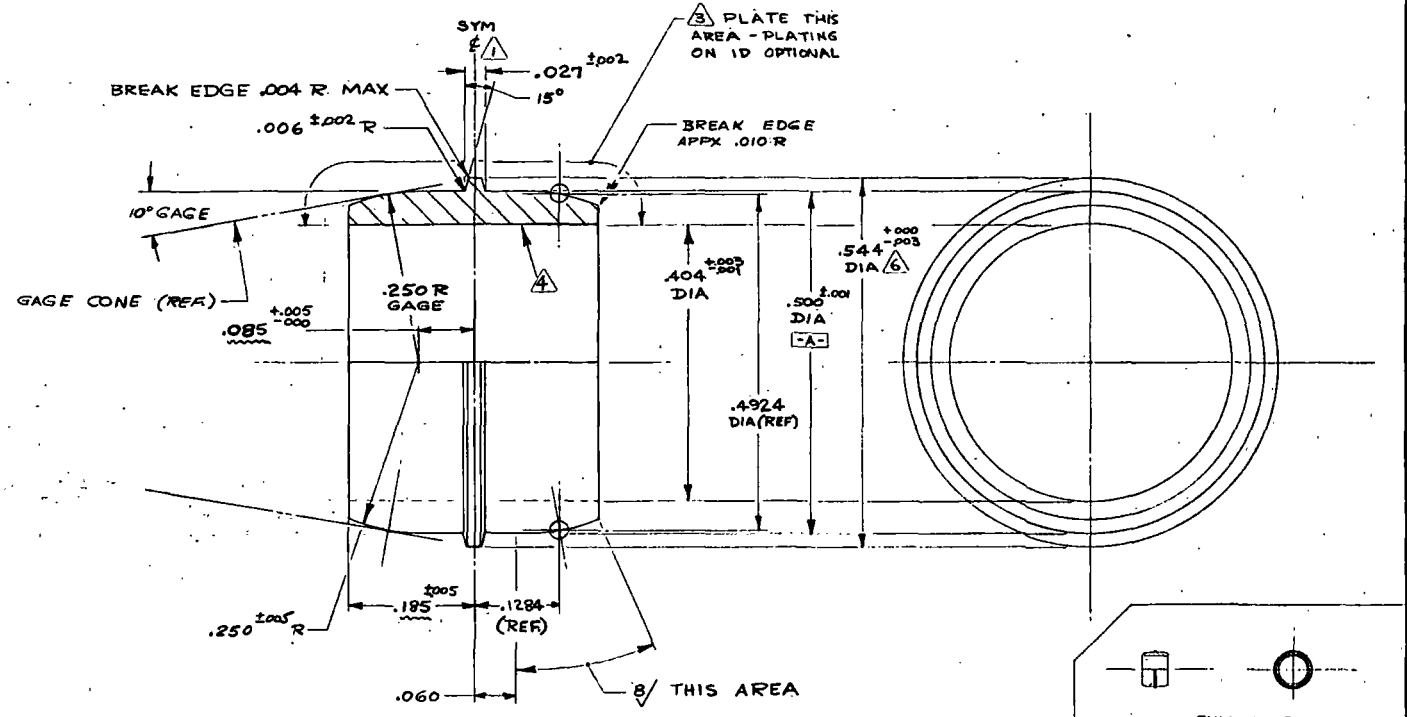
REVISIONS				
C.O. NO.	SYM	DESCRIPTION	DATE	APPROVAL
565-3065	NC	RELEASED FOR EDO	9/20/65	DSBurton 12-17-65



5659539

6 ⊙ A .002 TIR

5. ALL DIMENSIONS ARE BEFORE PLATING

4 ELECTROCHEM ETCH P/N & S/N HERE

3 MIL-G-45204 TYPE II CLASS 5 NOTED AREA

2 AGE HARDEN @ 1350°F FOR 10 HRS, FURNACE COOL TO 1200°F, HOLD @ 1200° FOR A TOTAL TIME OF 18-20 HRS

1 TRACEABILITY REQ'D PER BSS-19 CLASS A

NOTES (UNLESS OTHERWISE SPECIFIED)

NEXT ASSY	USED ON
APPLICATION	

WELD SYMBOLS PER AWS-A2.4-67

DIMENSIONAL SYMBOLS PER MIL-STD-8B

- FLATNESS & STRAIGHTNESS
- ANGULARITY
- PERPENDICULARITY
- PARALLELISM
- CONCENTRICITY
- TRUE POSITION
- ROUNDNESS
- SYMMETRY
- (M) DIMS MAXIMUM MATERIAL CONDITION
- (S) DIMS REGARDLESS OF FEATURE SIZE

UNLESS OTHERWISE SPECIFIED
DO NOT SCALE DRAWING
DIMENSIONS ARE IN INCHES
TOLERANCES
FRACTIONS DEC. ±1/64 ANGLES DEG. ±1/2° DEC. ±.25 ±.125 ±.030
±1/2 TOLERANCES OF HOLES SPECIFIED "DRILL" PER ANSI B94.11
MUST CONFORM TO ES-
MACHINED SURFACE 125 / PER MIL-STD-10A
CLASSIFICATION OF DEFECTIVES
CD PER SPM-2248 & MIL-STD-105B
REF 5124 - G.E.

SIGNATURES		DATE
DR BY	S.D. BURTON	12-16-65
CHK BY		12-20-65
ENGR CHK	SDBurton	12-17-65
APPD BY		
APPD BY		

ITEM NO.	DWG SIZE	QTY REQD	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL	MATERIAL SPECIFICATION	HEAT TREAT	FINISH	FINISH SPECIFICATION
				BAR	INCONEL 718	INCO /1	/2 /1	GOLD PLATE	/3

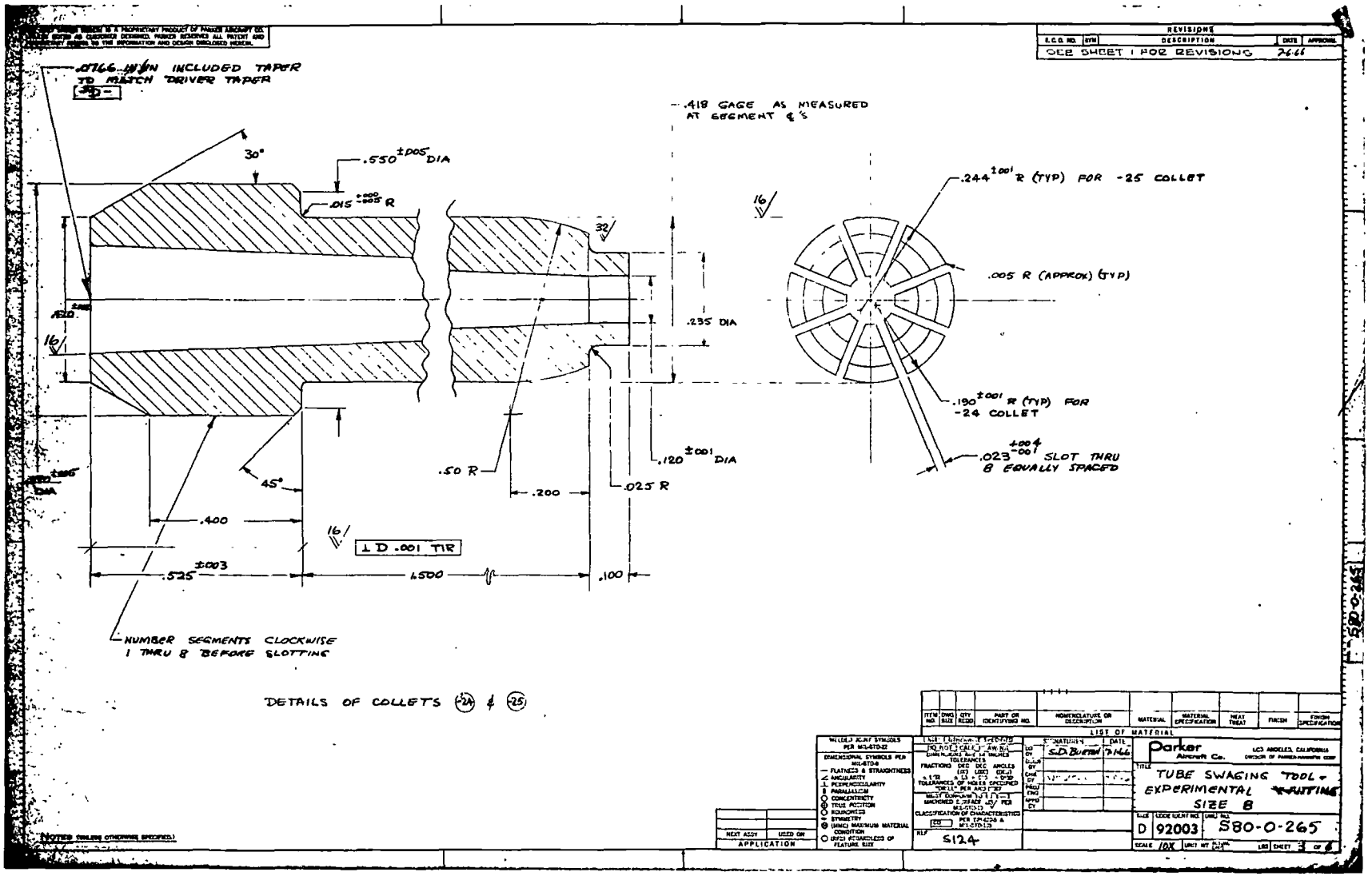
LIST OF MATERIAL

Parker Aircraft Co. — LOS ANGELES, CALIFORNIA — A DIVISION OF PARKER-HANNIFIN CORP.

TITLE: SEAL - X-FITTING, SIZE 8, 4500 PSI, 700°F, (EDO)

CODE IDENT NO.	SIZE	DWG NO.
92003	C	5659539

SCALE 10X / NOTED — UNIT WT ACTUAL .007 LBS — SHEET — OF —


.0766 MIN INCLUDED TAPER TO MATCH DRIVER TAPER
30°
.550 ±.005 DIA
.015 +.000 -.005 R
.418 GAGE AS MEASURED AT SEGMENT ℄'S
.244 ±.001 R (TYP) FOR -25 COLLET
.005 R (APPROX) (TYP)
.235 DIA
.190 ±.001 R (TYP) FOR -24 COLLET
.023 +.004 -.001 SLOT THRU 8 EQUALLY SPACED
.120 ±.001 DIA
.50 R
.200
.025 R
45°
.400
.525 ±.003
.500
.100
⊥ D .001 TIR
NUMBER SEGMENTS CLOCKWISE 1 THRU 8 BEFORE SLOTTING
DETAILS OF COLLETS (-24) & (-25)
REVISIONS
E.C.O. NO. | SYM | DESCRIPTION | DATE | APPROVAL
SEE SHEET 1 FOR REVISIONS 2666
LIST OF MATERIAL
Parker Aircraft Co.
TUBE SWAGING TOOL - EXPERIMENTAL CUTTING SIZE 8
D 92003 S80-0-265
SCALE 10X
S124
NEXT ASSY | USED ON
APPLICATION
S80-0-265

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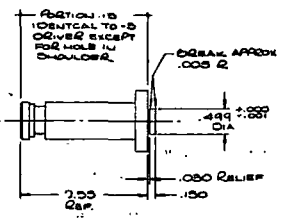
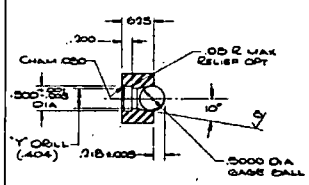
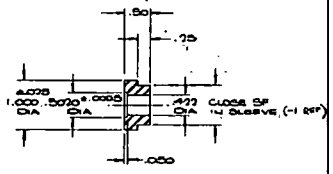
REVISIONS				
C.O. NO.	SYM	DESCRIPTION	DATE	APPROVAL
SEE SHEET 1 FOR REVISIONS			7-68	



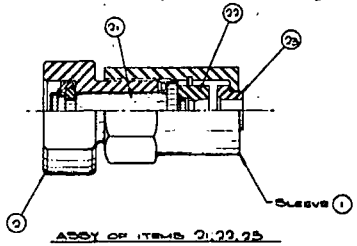
(21) DETAIL OF DRIVER SCALE: X 1



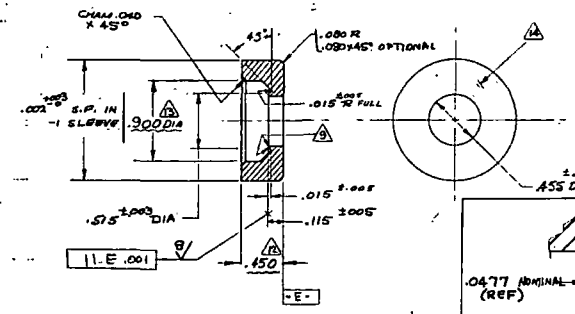
(22) DETAIL OF SOCKET SCALE: X 1



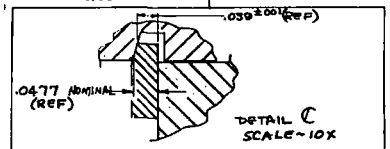
(25) BUSHING SCALE: X 1



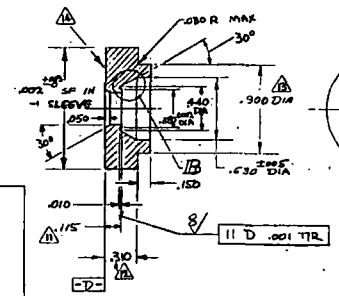
ASSY OF ITEMS 21, 22, 25

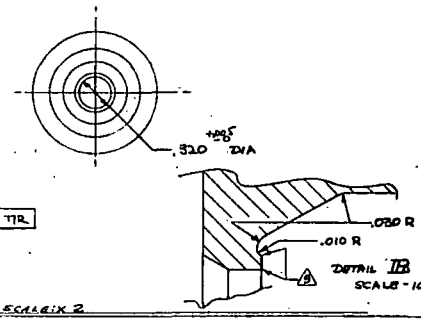


(17) DETAIL OF SUPPORT SCALE: 1 X 2

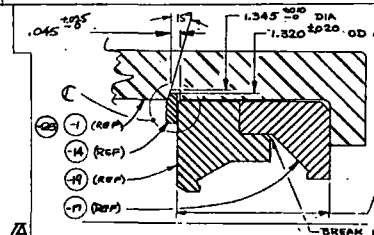


DETAIL C
SCALE ~ 10X





(19) DETAIL OF STOP SCALE 1X 2



DETAIL A
SCALE ~ 4X
NOTE - STOP & SUPT TO BE TIGHTLY RETAINED AXIALLY BY RUBBER RING

14 MARK "½ x .058" - ELECTROETCH OR ELECTROCHEM ETCH - DO NOT STAMP.

13 SELECTIVELY FIT NOTED DIAS TO .001 +.001 -.000 DIA. CLEARANCE

12 SUM OF DIM'S. TO BE ADJUSTED TO SUIT RET'G RING. FIT - SEE DETAIL A

11 SELECTIVELY FIT TO .005 +.002 -.000 CLEARANCE OF COLLET IN STOP & SUP'T.

NOTES (UNLESS OTHERWISE SPECIFIED)

LIST OF MATERIAL

ITEM NO.	DWG NO.	QTY REQ'D	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL	MATERIAL SPECIFICATION	HEAT TREAT	FINISH	FINISH SPECIFICATION

SIGNATURES		DATE
DR	G. MORSE	6-4-68
CH	S. BURTON	6-19-68
ENGR	S. BURTON	6-19-68
APP		
APP		

Parker Aircraft Co. LOS ANGELES, CALIFORNIA A DIVISION OF PARKER-HANNIFIN CORP.

TITLE: TUBE SWAGING TOOL EXPERIMENTAL - X FITTING SIZE 8

CODE IDENT NO.	SIZE	DRAWING NO.
92003	D	560-0-265

SCALE: WHEN X IS NOTED | UNIT BY: DECIMAL INCH | LAST SHEET 2 OF 2

APPLICATION: NEXT ASSY | USED ON

124

560-0-265

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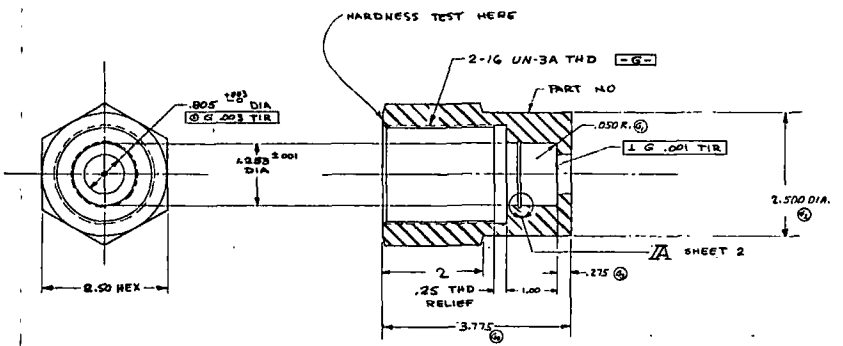
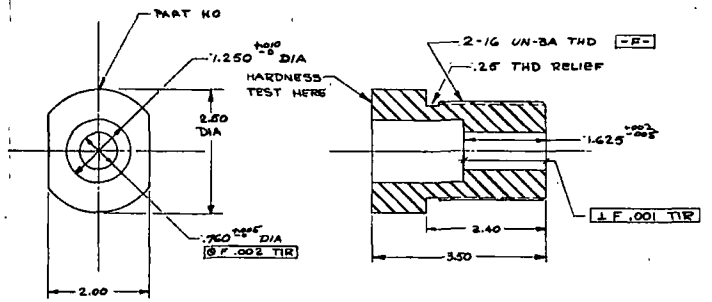
REVISIONS				
E.C.O. NO.	SYM	DESCRIPTION	DATE	APPROVAL
		SEE SHT 1 FOR REVISIONS		



(28) DETAIL OF SLEEVE



(27) DETAIL OF SCREW

NOTES (UNLESS OTHERWISE SPECIFIED)

ITEM NO.	DWG SIZE	QTY REQD	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL	MATERIAL SPECIFICATION	HEAT TREAT	FINISH	FINISH SPECIFICATION

LIST OF MATERIAL

WELDED JOINT SYMBOLS PER MIL-STD-12
DIMENSIONAL SYMBOLS PER MIL-STD-8
— FLATNESS & STRAIGHTNESS
∠ ANGULARITY
⊥ PERPENDICULARITY
∥ PARALLELISM
◎ CONCENTRICITY
⊕ TRUE POSITION
○ ROUNDNESS
⌯ SYMMETRY
Ⓜ (MMC) MAXIMUM MATERIAL CONDITION
Ⓢ (RFS) REGARDLESS OF FEATURE SIZE

UNLESS OTHERWISE SPECIFIED
DO NOT SCALE DRAWING
DIMENSIONS ARE IN INCHES
TOLERANCES
FRACTIONS ± 1/32 | DEC .XX ± .03 | DEC .XXX ± .010 | ANGLES (DEG) ± 0°30'
TOLERANCES OF HOLES SPECIFIED "DRILL" PER ANSI B18.2
MUST CONFORM TO ES 1—1
MACHINED SURFACE 125 / PCS MIL-STD-10
CLASSIFICATION OF CHARACTERISTICS PER SPI-6218 & MIL-STD-100
CR
REF S124-GE/NASA

SIGNATURES	DATE
DR S. D. Burton	8-12-66
DSGN BY	
CHK BY	
PROJ ENG S.D. Burton	8-12-66
APVD BY	

Parker Aircraft Co. LOS ANGELES, CALIFORNIA DIVISION OF PARKER-HANNIFIN CORP

TITLE: TUBE SWAGING TOOL-EXPERIMENTAL X-FITTING, SIZE 8

SIZE	CODE IDENT NO.	DWG NO.
D	92003	580-0-265

SCALE FULL | UNIT WT ACTUAL LBS | SHEET 5 OF 6

NEXT ASSY	USED ON
APPLICATION	

580-0-265

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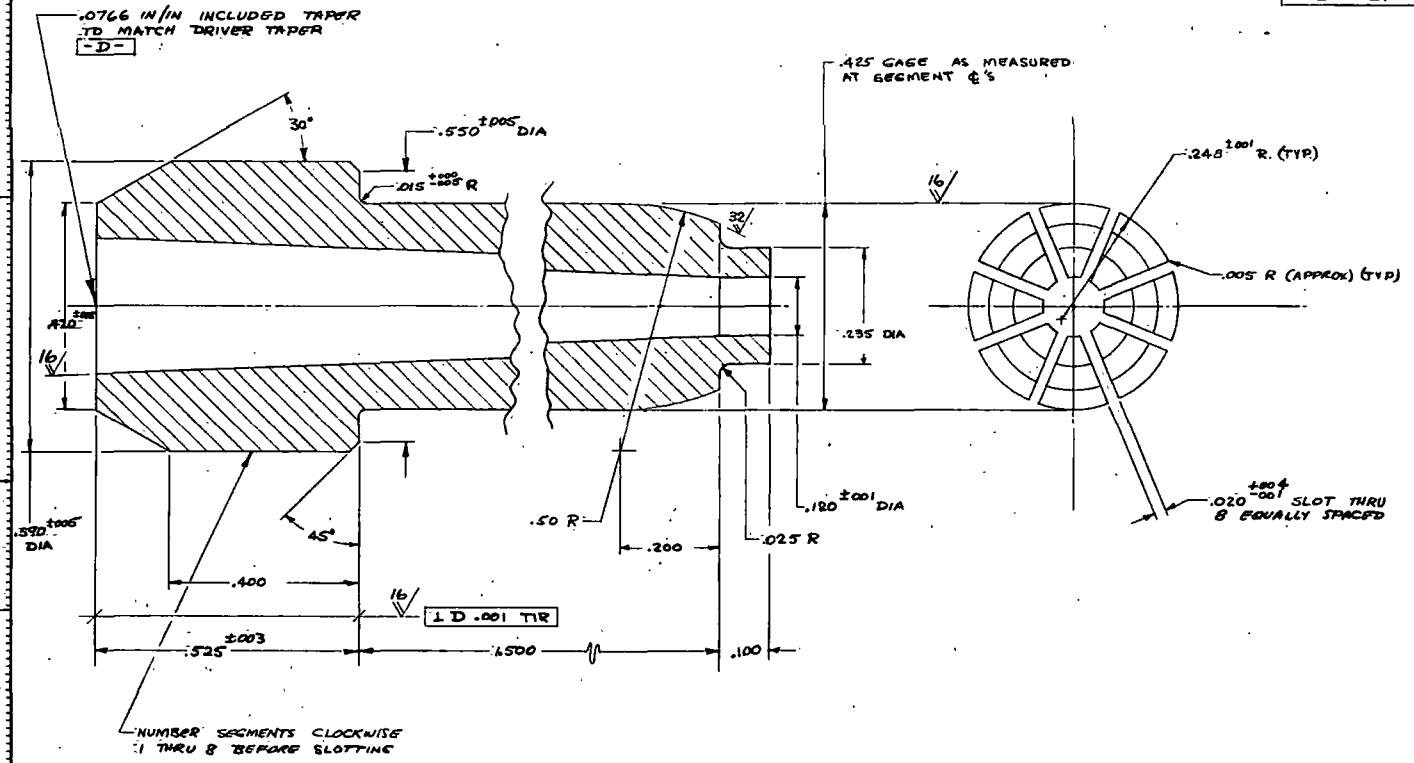
REVISIONS				
E.C.O. NO.	SYM	DESCRIPTION	DATE	APPROVAL
SEE SHEET 1 FOR REVISIONS				



DETAILS OF COLLET (26)

NOTES (UNLESS OTHERWISE SPECIFIED)

ITEM NO.	DWG SIZE	QTY REQD	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL	MATERIAL SPECIFICATION	HEAT TREAT	FINISH	FINISH SPECIFICATION

LIST OF MATERIAL

NEXT ASSY	USED ON
APPLICATION	

WELDED JOINT SYMBOLS PER MIL-STD-22

DIMENSIONAL SYMBOLS PER MIL-STD-8
- FLATNESS & STRAIGHTNESS
- ANGULARITY
- PERPENDICULARITY
- PARALLELISM
- CONCENTRICITY
- TRUE POSITION
- ROUNDNESS
- SYMMETRY
- (Ⓜ) (MMC) MAXIMUM MATERIAL CONDITION
- (Ⓢ) (RFS) REGARDLESS OF FEATURE SIZE

UNLESS OTHERWISE SPECIFIED
DO NOT SCALE DRAWING
DIMENSIONS ARE IN INCHES
TOLERANCES
FRACTIONS ±1/32 DECIMALS .XX ±.010 .XXX ±.005 ANGLES (.01) (.001) (DEG) ±0°30'
TOLERANCES OF HOLES SPECIFIED "DRILL" PER ANSI B 94.11M
MUST COMPLY TO ST [—] MACHINED SURFACE 125/ PER MIL-STD-10
CLASSIFICATION OF CHARACTERISTICS PER SAE-ICSA & MIL-STD-100
REF 5124

SIGNATURES		DATE
DR BY	C.O. HERNARD	8-9-66
CHKD BY		
ENGR BY	EMERY	9/16/66
MANUF BY		
QMCL		
APPD BY		

Parker Aircraft Co. — LOS ANGELES, CALIFORNIA — DIVISION OF PARKER-HANNIFIN CORP

TITLE: TUBE SWAGING TOOL - EXPERIMENTAL 4-FITTING SIZE 8

SIZE	CODE IDENT NO.	DWG NO.
D	92003	580-0-265

SCALE 10X — WEIGHT: ACTUAL CALC — LBS — SHEET 4 OF 6

580-0-265

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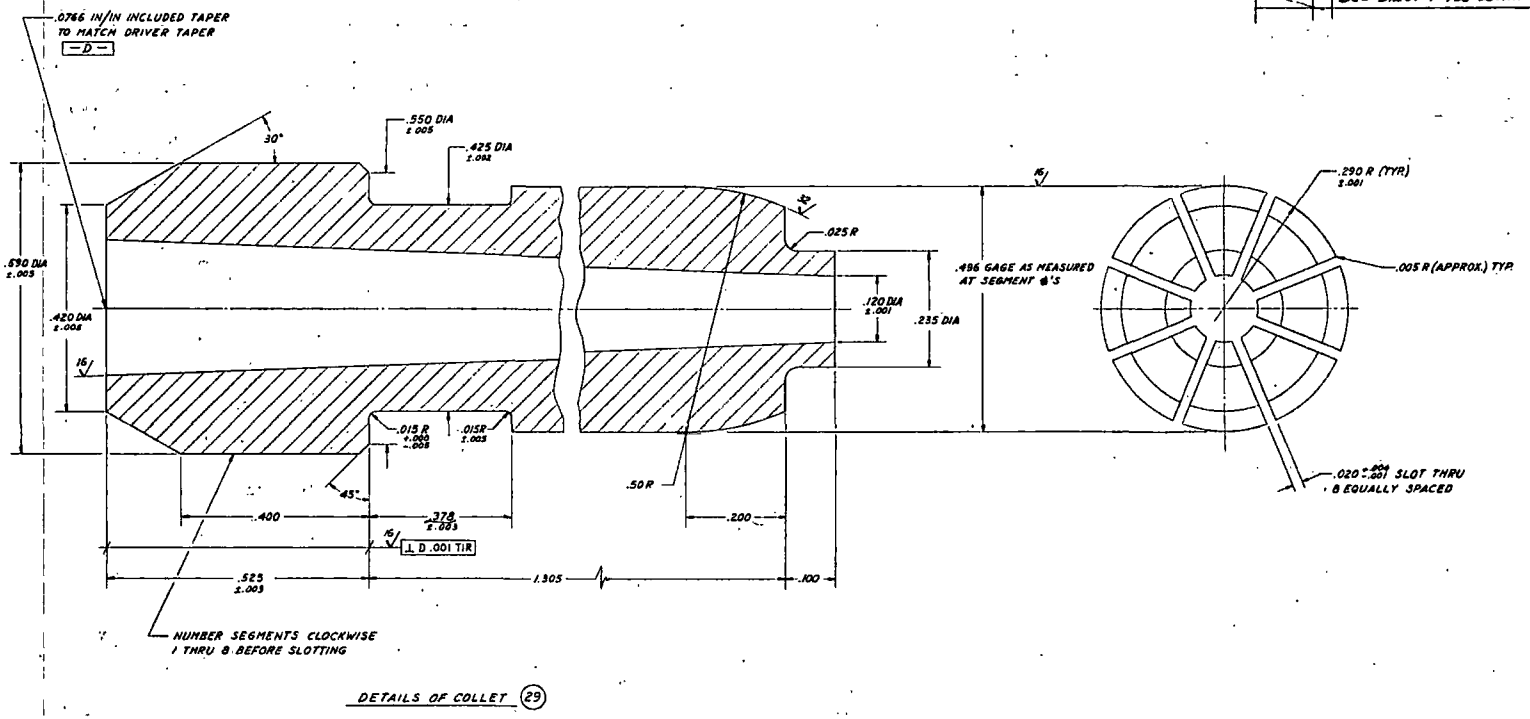
REVISIONS				
E.C.O. NO.	SYM	DESCRIPTION	DATE	APPROVAL
-		SEE SHEET 1 FOR REVISIONS		



DETAILS OF COLLET (29)

S80-0-265

ITEM NO.	DWG SIZE	QTY REQD	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL	MATERIAL SPECIFICATION	HEAT TREAT	FINISH	FINISH SPECIFICATION

LIST OF MATERIAL

NEXT ASSY	USED ON
APPLICATION	

WELDED JOINT SYMBOLS PER MIL-STD-22

DIMENSIONAL SYMBOLS PER MIS-STD-8
— FLATNESS & STRAIGHTNESS
∠ ANGULARITY
⊥ PERPENDICULARITY
∥ PARALLELISM
◎ CONCENTRICITY
⊕ TRUE POSITION
○ ROUNDNESS
⌭ SYMMETRY
Ⓜ DMIC MAXIMUM MATERIAL CONDITION
Ⓢ DMIC REGARDLESS OF FEATURE SIZE

UNLESS OTHERWISE SPECIFIED
DO NOT SCALE DRAWING
DIMENSIONS ARE IN INCHES
TOLERANCES
FRACTIONS DEC ±.01 ANGLES ±.005 (.00) ±.02 (.000) ±.010 ±0°30'
TOLERANCES OF HOLES SPECIFIED "TRUE" PER ANSI B28.7
MUST CONFORM TO EE 1-1
MACHINED SURFACE 125 PER MIL-STD-10
CLASSIFICATION OF CHARACTERISTICS PER AFR 4274-8 & MIL-STD-100
REF 3131 NASA

SIGNATURES		DATE
DR BY	dB VOURCHEKO	8-22-66
DESGN BY	S. BURTON	
CHK BY		9-27-66
ENGG APPD BY		
APPD BY		

Parker Aircraft Co. — LOS ANGELES, CALIFORNIA — DIVISION OF PARKER-HANNIFIN CORP

TITLE: TUBE SWAGING TOOL
EXPERIMENTAL X-FITTING
SIZE 8

SIZE	CODE IDENT NO.	DWG NO.
D	92003	S80-0-265

SCALE 10 X | UNIT WT. NOMINAL GAGE | LBS | SHEET 6 OF 6

NOTES (UNLESS OTHERWISE SPECIFIED)

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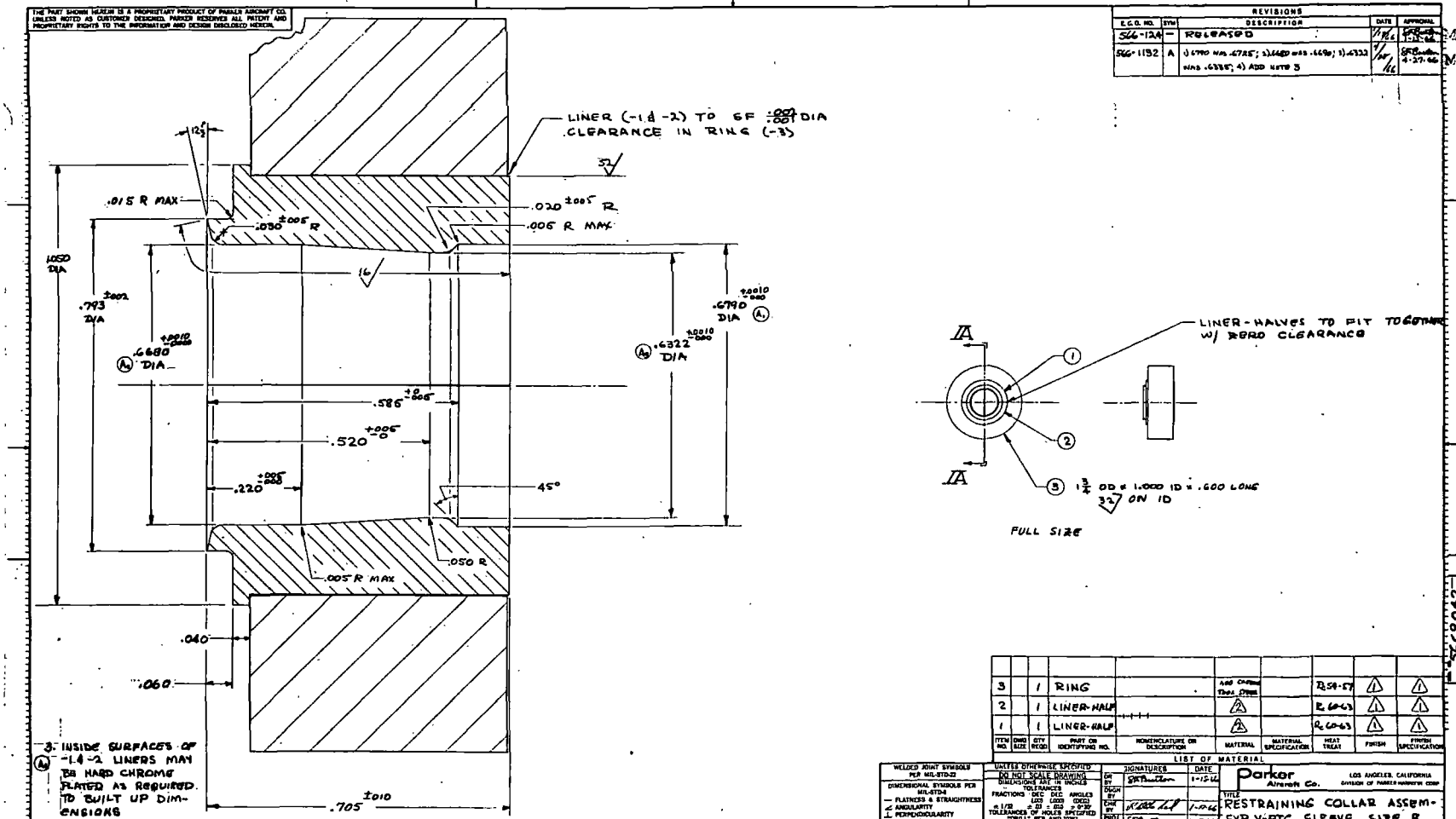
REVISIONS				
E.C.O. NO.	SYM	DESCRIPTION	DATE	APPROVAL
546-124	—	RELEASED	7/16/64	[illegible] 7-28-64
546-1152	A	1) .6790 WAS .6785; 2) .6680 WAS .6690; 3) .6322 WAS .6325; 4) ADD NOTE 3	9/30/66	[illegible] 4-27-66



3. INSIDE SURFACES OF -1 & -2 LINERS MAY BE HARD CHROME PLATED AS REQUIRED TO BUILT UP DIMENSIONS

2 NON-DEFORMING TOOL STEEL - CARPENTER "STENTOR", HALCOMB "KETOS", OR EQUIV.

1 BLACK OXIDE PER MIL-C-13924 CLASS 1

NOTES (UNLESS OTHERWISE SPECIFIED)

ITEM NO.	DWG SIZE	QTY REQD	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL	MATERIAL SPECIFICATION	HEAT TREAT	FINISH	FINISH SPECIFICATION
3		1	RING		AND CHROME TOOL STEEL 2		R 58-67	1	1
2		1	LINER-HALF		2		R 60-63	1	1
1		1	LINER-HALF		2		R 60-63	1	1

LIST OF MATERIAL

WELDED JOINT SYMBOLS PER MIL-STD-22	UNLESS OTHERWISE SPECIFIED	SIGNATURES	DATE
DIMENSIONAL SYMBOLS PER MIL-STD-8 — FLATNESS & STRAIGHTNESS ∠ ANGULARITY ⊥ PERPENDICULARITY ∥ PARALLELISM ◎ CONCENTRICITY ⊕ TRUE POSITION ○ ROUNDNESS ⌯ SYMMETRY Ⓜ DIMEN. MAXIMUM MATERIAL CONDITION Ⓢ DIMEN. REGARDLESS OF FEATURE SIZE	DO NOT SCALE DRAWING. DIMENSIONS ARE IN INCHES. TOLERANCES: FRACTIONS ± 1/32, DEC .XX ± .03, .XXX ± .010, ANGLES (DEG) ± 1°30'. TOLERANCES OF HOLES SPECIFIED "DRILL" PER ANSI B32.1. MUST CONFORM TO 125 — MACHINED SURFACE 125/ PER MIL-STD-13. CLASSIFICATION OF CHARACTERISTICS PER SPEC-204 & MIL-STD-105. REF 5124 GO/NA1A	DR BY [illegible]	9-15-66
		DSGN BY	
		CHK BY [illegible]	1-12-66
		PROJ ENG [illegible]	1-12-66
		APVD BY	
		5669526 SLEEVE	

NEXT ASSY	USED ON
APPLICATION	

Parker Aircraft Co. — LOS ANGELES, CALIFORNIA — DIVISION OF PARKER-HANNIFIN CORP

TITLE: RESTRAINING COLLAR ASSEM-EXP V-PTC. SLEEVE, SIZE 8, 4500 PSI, 700°F, LEDO

SIZE	CODE IDENT NO.	DWG NO.
D	92003	5669042

SCALE Noted | UNIT WT ACTUAL LBS | SHEET 1 OF 1

5669042

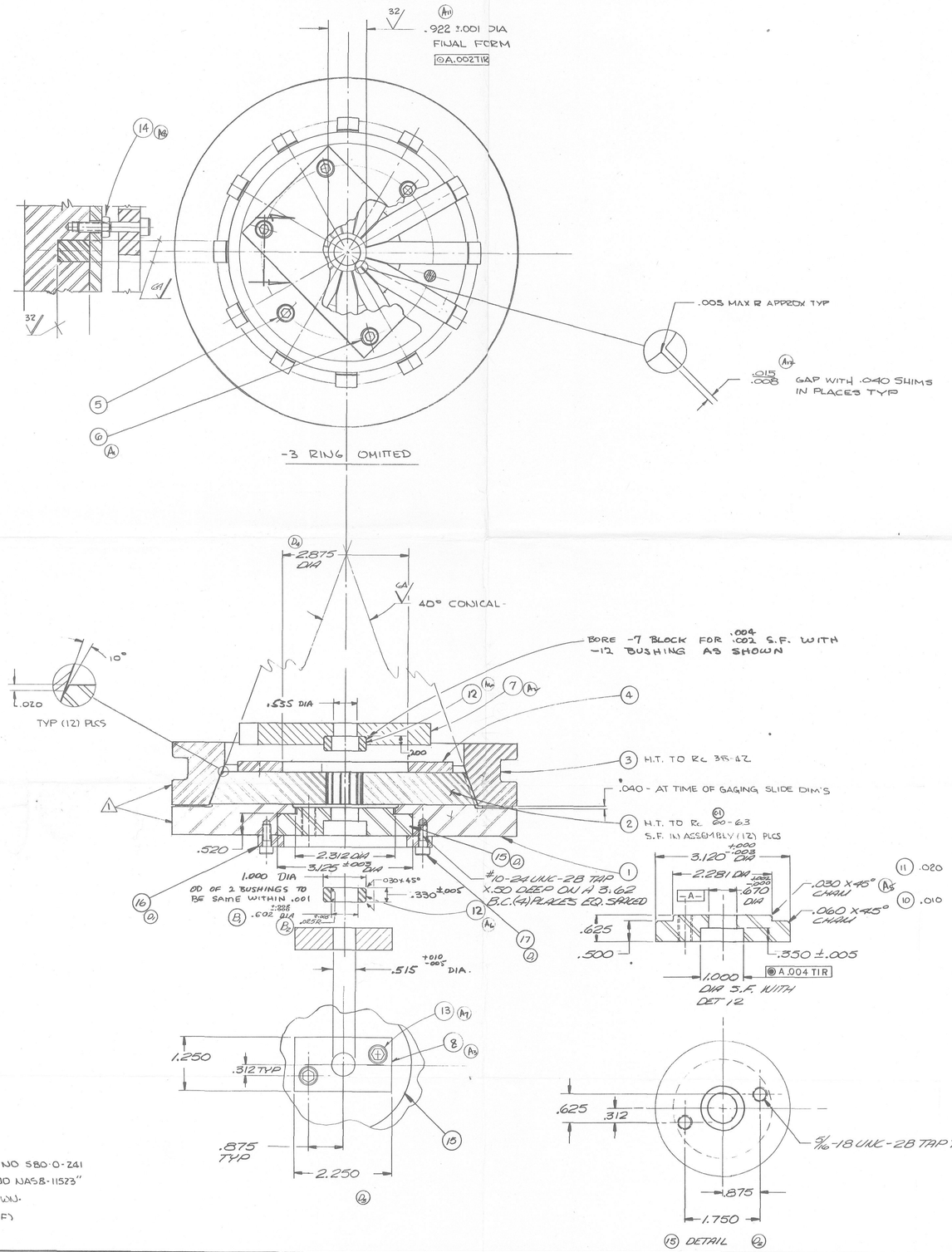
FOLDOUT FRAME 1

FOLDOUT FRAME 2

FOLDOUT FRAME 3

THE PART SHOWN HEREIN IS A PROPRIETARY PRODUCT OF PARKER AIRCRAFT CO. UNLESS NOTED AS CUSTOMER DESIGNED. PARKER RESERVES ALL PATENT AND PROPRIETARY RIGHTS TO THE INFORMATION AND DESIGN DISCLOSED HEREIN.

REVISIONS				
C. O. NO.	SYM	DESCRIPTION	DATE	APPROVAL
566-379	-	RELEASED FOR PROD.	2-26-6	
566-139	A_{15}	SEE E.C.O.	1-31-66	SF Burton 1-31-66
526-477	B_{15}	D.602 +.003 -.000 DIA WAS .676 +.003 -.000 DIA ADDED .025 R. +.005 -.005	2/28/66	SF Burton 2-31-66
TCO-083	C	SEE T.CO FOR CHANGE	5/4/66	EMEH
TCORR8	D	SEE T.C.O. FOR REV 1 THRU 3	7-14-66	EMEH



ITEM NO.	DWG SIZE	QTY REQD	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL	MATERIAL SPECIFICATION	HEAT TREAT	FINISH	FINISH SPECIFICATION
17		4	SOC HD SCR	#10-24 x 1/2 LG	STEEL	COML	—	—	—
(2) 16		1	RING	4 DIA x 3/16	STEEL	COML	—	—	—
15		1	COLLAR	3 1/4 DIA x 5/16	300 SER. 300% STEEL	COML	Rc 50	—	—
(A8) 14		4	HEX NUT	1/4-20 NC	STEEL	COML		—	
(A7) 13		2	SOC. HD. CAP. SCR.	5/16-18 x 1 1/4 LG	STEEL	COML	—		
(A6) 12		2	BUSHING	1 7/16 x 1/2	4130	COML	NORMALIZED		
11		6	SHIM-SPLIT	.020 x 8 DIA	STL. SHIM STOCK	COML			
(A5) 10		4	SHIM-SPLIT	.010 x 8 DIA	STL SHIM STOCK	COML			
(A4) 9		4	SHIM BLOCKS	1/4 x 5/8 x 4	STEEL	COML			
(A3) 8		1	BLOCK-BOTTOM	1/2 x 1 1/4 x 2 1/4	ALUM.	COML			
(A2) 7		1	BLOCK-TOP	1/2 x 3 x 4 1/2	ALUM.	COML			
(A1) 6		4	SOC HD CAPSC	1/4-20 NC x 1 3/4		COML			
5		6	SOC HD CAPSC	1/4-20 UNC x 1		COML			
(D4) 4		1	PLATE	5/16 x 5" DIA	CRS	COML	—	—	—
3		1	RING	1 1/2 x 8 DIA	OHTS	COML	Rc 38-42	—	—
2		12	FINGER	1/2 x 3/8 x 2 3/8	OHTS FLT GRD	COML	Rc 60-63 (C1)	—	—
1		1	BASE	1 1/2 x 8" DIA	HRS	COML	—	—	—

LIST OF MATERIAL

WELD SYMBOLS PER JAN-STD-19
DIMENSIONAL SYMBOLS PER MIL-STD-18
FLATNESS & STRAIGHTNESS
ANGULARITY
PERPENDICULARITY
PARALLELISM
CONCENTRICITY
TRUE POSITION
ROUNDNESS
SYMMETRY
(M) (MMC) MAXIMUM MATERIAL CONDITION
(S) (RFS) REGARDLESS OF FEATURE SIZE

NEXT ASSY	USED ON
APPLICATION	

UNLESS OTHERWISE SPECIFIED
DO NOT SCALE DRAWING
DIMENSIONS ARE IN INCHES
TOLERANCES
FRACTIONS ±1/32 | DEC ±.005 | ANGLES ±1/2°
TOLERANCES OF HOLES SPECIFIED "DRILL" PER ANSI B94.11
MUST CONFORM TO ES
MACHINED SURFACE 125 PER MIL-STD-18A
CLASSIFICATION OF DEFECTIVES
CD PER SPI-422-5 & MIL-STD-105D
REF 124

SIGNATURES		DATE
DR BY	G. Horne	2-26-65
CHK BY		2-27-5
PROJ ENGR		2-24-65
APPD BY		
APPD BY	EHE	8-26-65

GE/NASA

Parker Aircraft Co. LOS ANGELES, CALIFORNIA A DIVISION OF PARKER-HANNIFIN CORP.

TITLE: COLLAR SWAGING TOOL #2
EXPERIMENTAL - X-FITTING
SIZE-8

CODE IDENT NO.	SIZE	DWG NO.
92003	E	S80-0-241

SCALE FULL | UNIT WT ACTUAL CALC | LBS | SHEET 1 OF 1

SHEET 2 IS 'C' SIZE

S80-0-241

NOTES (UNLESS OTHERWISE SPECIFIED)

1. STEEL STAMP "S-124 TOOL NO S80-0-241 NASA PROPERTY CONTR NO NASB-11523"
2. SCALE ALL DIMS NOT SHOWN.
3. DIE STROKE = .440 (REF)

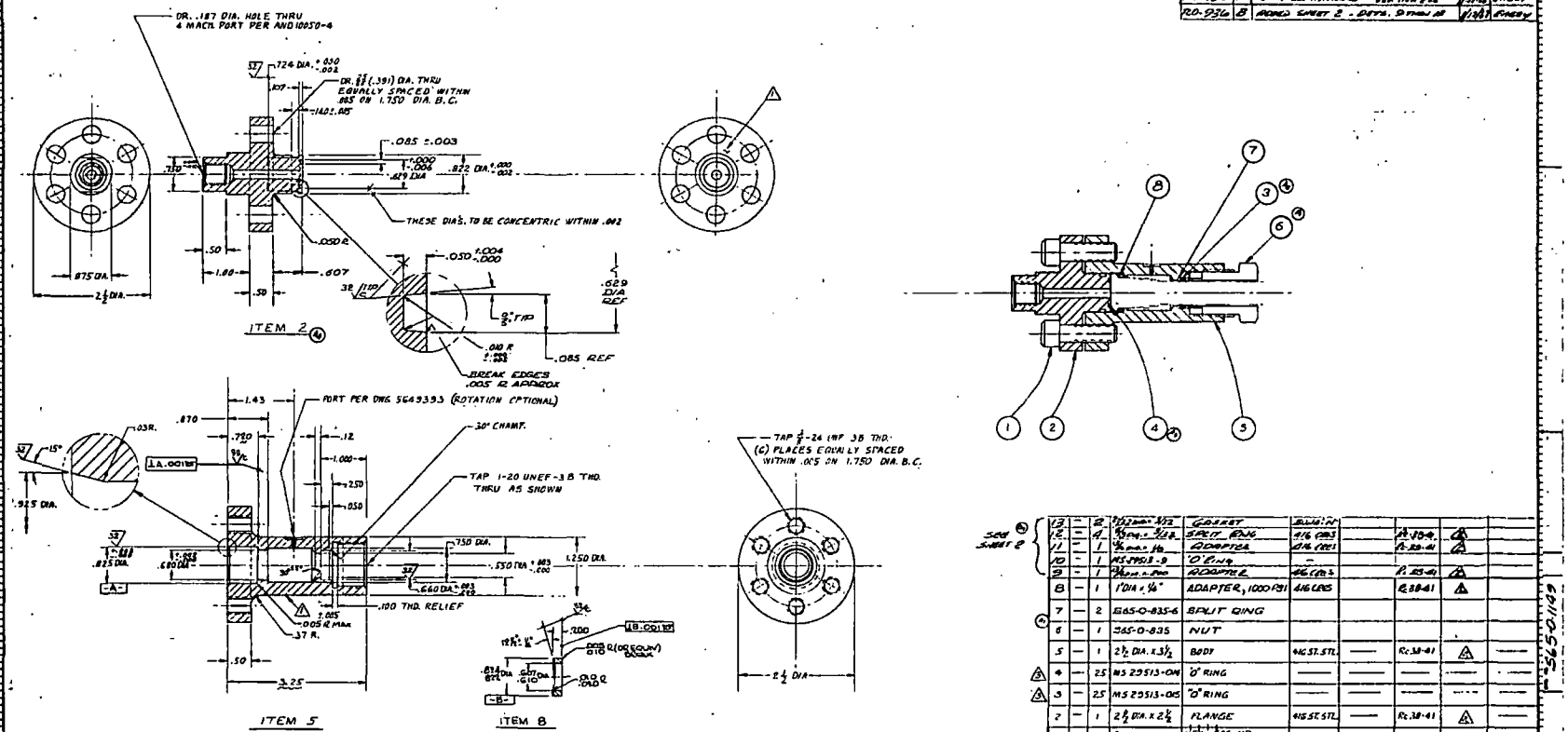
FOLDOUT FRAME 4

FOLDOUT FRAME 6

FOLDOUT FRAME 7

THE PART SHOWN HEREIN IS A PROPRIETARY PRODUCT OF PARKER AIRCRAFT CO. UNLESS NOTED AS CUSTOMER DESIGNED. PARKER RESERVES ALL PATENT AND PROPRIETARY RIGHTS TO THE INFORMATION AND DESIGN DISCLOSED HEREIN.

REVISIONS				
E.C.O. NO.	SYM	DESCRIPTION	DATE	APPROVAL
7C0-418	AC	RELEASED	1-24-66	[illegible]
20-736	A	[illegible]	4-11-66	[illegible]
20-956	B	ADDED SHEET 2 - DETS. D THRU H	6-16-66	[illegible]



ITEM NO.	DWG SIZE	QTY REQD	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL	MATERIAL SPECIFICATION	HEAT TREAT	FINISH	FINISH SPECIFICATION
13	—	2	1.0 mm x 4.2	GASKET	SILICONE				
12	—	4	⅜ DIA. x .328	SPLIT RING	416 CRES		R. 80-41	A	
11	—	1	⅜ DIA. x ⅛	ADAPTER	416 (303)		R. 80-41	A	
10	—	1	MS 29513-9	"O" RING	—	—	—	—	—
9	—	1	⅜ DIA. x .210	ADAPTER	416 CRES		R. 80-41	A	
8	—	1	1" DIA x ⅛"	ADAPTER, 1000 PSI	416 CRES		R. 80-41	A	
7	—	2	565-0-835-6	SPLIT RING					
6	—	1	565-0-835	NUT					
5	—	1	2½ DIA. x 3½	BODY	416 ST. STL.	—	RC. 38-41	A	—
4	—	25	MS 29513-014	"O" RING	—	—	—	—	—
3	—	25	MS 29513-005	"O" RING	—	—	—	—	—
2	—	1	2½ DIA. x 2¼	FLANGE	416 ST. STL.	—	RC. 38-41	A	—
1	—	6	⅜-24 X 1	HEX. SOC. HD. CAP SCREW	STEEL	—	—	A	—

LIST OF MATERIAL

See Sheet 2

APPLICATION		
1000 PSI	5649888	
4500 PSI	5G5195226	
NEXT ASSY	USED ON	

UNLESS OTHERWISE SPECIFIED
DO NOT SCALE DRAWING
DIMENSIONS IN INCHES
TOLERANCES
FRACTIONS ± DEC ± ANGLES
.X ± .XX ± .XXX ±
MUST CONFORM TO ES 1—1
MACHINED SURFACE 125/ PER MIL-STD-10
CLASSIFICATION OF CHARACTERISTICS PER BPH-1224 & MIL-STD-105
124-C1 & 121-2a

SIGNATURES	DATE
G.A. HERMANN	6-21-66
G.A. HERMANN	6-21-66
[illegible]	6/21/66
[illegible]	6/21/66
[illegible]	6/21/66

5649888-1000 PSI
5G5195226-4500 PSI

Parker Aircraft Co. · LOS ANGELES, CALIFORNIA · DIVISION OF PARKER HANNIFIN CORP.

TITLE: LEAKAGE COLLECTOR — TUBE-SLEEVE SUB ASSEMBLY SIZE 8, 4500 PSI 1,000 PSI

SIZE	CODE IDENT NO.	DWG NO.
D	92003	565-0-1149

SCALE FULL | UNIT WT | MATERIAL LIST | LBS | SHEET 1 OF 2

SEE SHEET 2D FOR ⅜" I.D. PORT.

△ QUANTITY INCLUDES SPARES.
△ PASSIVATE PER ES F59-2.
△ ELECTRO CHEM. ETCH HERE: NAS 8-11523, NASA PROPERTY, S-124, # TOOL NO

NOTES (UNLESS OTHERWISE SPECIFIED)

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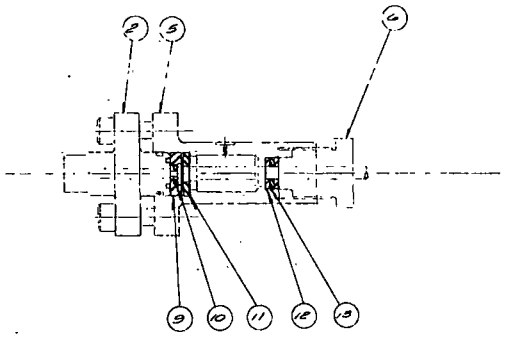
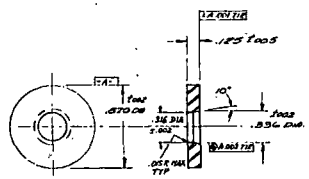
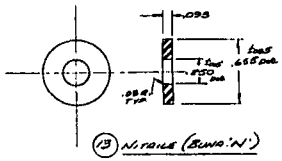
REVISIONS			
E.C.O. NO.	SYM	DESCRIPTION	DATE / APPROVAL
SEE SHEET 1 FOR LATEST REV.			

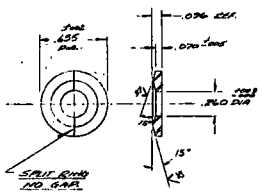




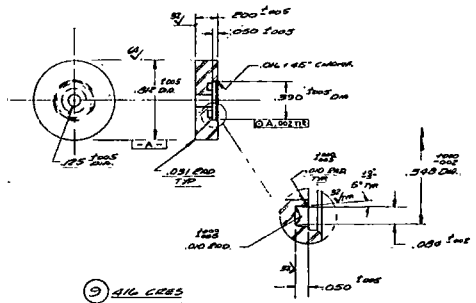
(11) 416 CRES
SCALE: 8/1



(13) N. STEEL (BUNO. 'N')



(12) 416 CRES
SCALE: 8/1



(9) 416 CRES
SCALE: 8/1

SEE SHEET 1 FOR B/M

ITEM NO.	DWG SIZE	QTY REQD	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL	SPEC.	HEAT TREAT	FINISH	FINISH SPECIFICATION
1	D	1	565-0-1149	LEAKAGE COLLECTOR 1/8" FITTING.					
2		1							
3		1							
4		1							
5		1							
9		1							
10		1							
11		1							
12		1							
13		1							

LIST OF MATERIAL

5- QUANTITY INCLUDES SPARES

2- SCALE DWGS NOT GIVEN

1- REQ. IN CONTAINER WITH TL.NR. P/N 5LL9491
NAS-8-20572, NASA PROP ON IDENT. TAG.

NOTES (UNLESS OTHERWISE SPECIFIED)

NEXT ASSY	USED ON
APPLICATION	

WELDED JOINT SYMBOLS PER MIL-STD-22

DIMENSIONAL SYMBOLS PER MIL-STD-8
- FLATNESS & STRAIGHTNESS
- ANGULARITY
- PERPENDICULARITY
- PARALLELISM
- CONCENTRICITY
- TRUE POSITION
- ROUNDNESS
- SYMMETRY
- (M) GMMC MAXIMUM MATERIAL CONDITION
- (RFS) REGARDLESS OF FEATURE SIZE

UNLESS OTHERWISE SPECIFIED
DO NOT SCALE DRAWING
DIMENSIONS ARE IN INCHES
TOLERANCES
FRACTIONS DEC ±.005 ANGLES ±1°
.XX ±.010 .XXX ±.005
TOLERANCES OF HOLES SPECIFIED "DRILL" PER ANSI B18.1
SHALL CONFORM TO 1.6 MACHINED SURFACE UON PER MIL-STD-10
CLASSIFICATION OF CHARACTERISTICS PER SPI-2246 & MIL-STD-105
KLF
131-A2

SIGNATURES		DATE
DR BY	EMody	11-1-67
DSGN BY	E. Mouthaka	11-6-67
CHK BY	E. Mouthaka	11-7-67
PROJ ENG		
APPD BY		

5LL9491

Parker Aircraft Co. LOS ANGELES, CALIFORNIA
DIVISION OF PARKER-HANNIFIN CORP.

TITLE LEAKAGE COLLECTOR 1/8" FITTING.

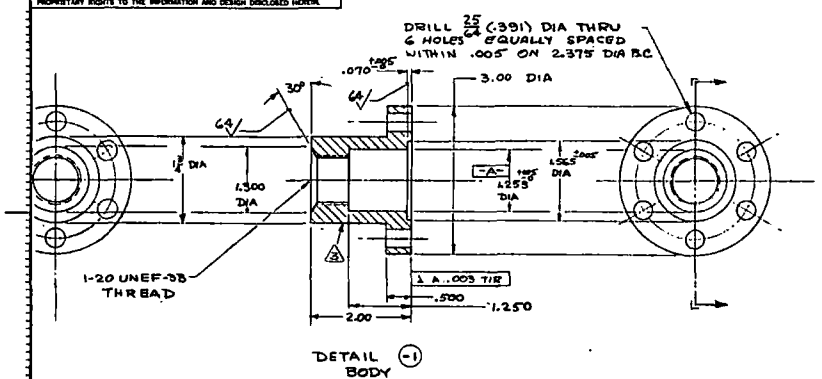
SIZE	CODE IDENT NO.	DWG NO.
D	92003	565-0-1149

SCALE | UNIT WT ACTUAL CALC. LBS | SHEET 2 OF 2

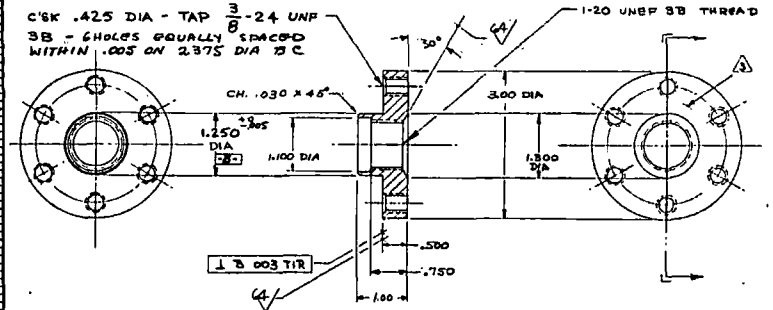
565-0-1149

THE PART SHOWN HEREIN IS A PROPRIETARY PRODUCT OF PARKER AIRCRAFT CO. UNLESS NOTED AS CUSTOMER DESIGNED, PARKER RESERVES ALL PATENT AND PROPRIETARY RIGHTS TO THE INFORMATION AND DESIGN DISCLOSED HEREIN.

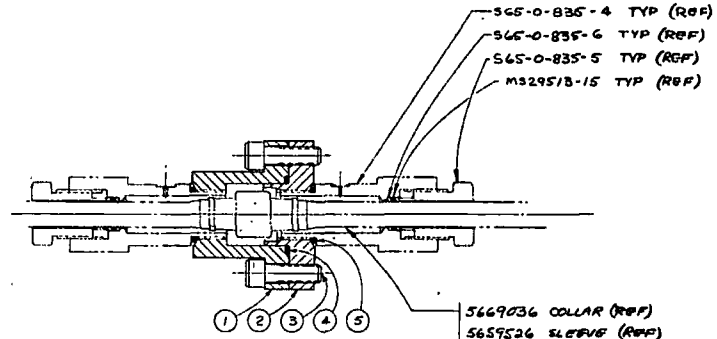
REVISIONS				
E.C.O. NO.	SYM	DESCRIPTION	DATE	APPROVAL
566-142	—	RELEASE	7/14/66	



DETAIL (-1) BODY



DETAIL (-2) FLANGE



ITEM NO.	DWG SIZE	QTY REQD	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL	MATERIAL SPECIFICATION	HEAT TREAT	FINISH	FINISH SPECIFICATION
5		25	MS28775-213	O-RING					
4		12	MS28775-124	O-RING					
3		6	3/8-24 x 1 1/16	SOCKET HEAD CAP SCREW					
2		1		FLANGE	4130	COM'L	NORM.	2	2
1		1		BODY	4130	COM'L	NORM.	2	2

LIST OF MATERIAL

3669058

3 ELECTRO-CHEM ETCH P/N HERE
2 BLACK OXIDE PER MIL-C-13924A CLASS 1
1 ADDITIONAL QUANTITY INCLUDES SPARES

NOTES: (UNLESS OTHERWISE SPECIFIED)

NEXT ASSY	USED ON
APPLICATION	

WELDED JOINT SYMBOLS PER MIL-STD-22

DIMENSIONAL SYMBOLS PER MIL-8104
— FLATNESS & STRAIGHTNESS
∠ ANGULARITY
⊥ PERPENDICULARITY
// PARALLELISM
◎ CONCENTRICITY
⊕ TRUE POSITION
⌓ ROUNDNESS
⌯ SYMMETRY
Ⓜ (BASIC) MAXIMUM MATERIAL CONDITION
Ⓢ (RFD) REGARDLESS OF FEATURE SIZE

UNLESS OTHERWISE SPECIFIED
DO NOT SCALE DRAWING
TOLERANCES ARE IN INCHES
TOLERANCE'S
FRACTIONS DEC ± .01 ANGLES ± .5°
.XX ± .02 .XXX ± .010
TOLERANCES OF HOLES SPECIFIED "DRILL" PER ANSI B212
MUST CONFORM TO 125 [—] MACHINED SURFACE I/S/ PER MIL-STD-10
CLASSIFICATION OF CHARACTERISTICS PER SPI-6094 & MIL-STD-105
REF 124 - GE/NASA

SIGNATURES	DATE
DWN BY J. D. BURTON	7-8-66
DSGN BY	
CHK BY	
ENGG APPD BY E.F. Burton	7-8-66
APPD BY	

Parker Aircraft Co. LOS ANGELES, CALIFORNIA DIVISION OF PARKER-HANNIFIN CORP

TITLE LEAKAGE COLLECTOR - BXR Y-FTG., SIZE 8, 4500 PSI, 700°F, (GDO)

SIZE	CODE IDENT NO.	DWG NO.
D	92003	5669058

SCALE FULL UNIT WT ACTUAL CALC LBS SHEET 1 OF 1

APPENDIX II

Appendix II

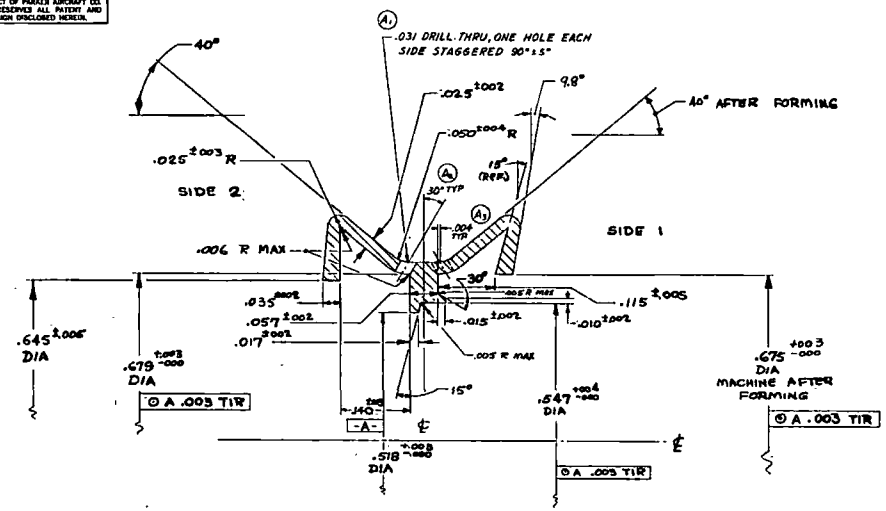
HALF-INCH, 1000-PSI CONNECTOR DRAWINGS

Drawings for the half-inch, 1000-psi connector are reproduced in this Appendix. The following drawings are included:

Part	Parker Aircraft Company Drawing No.
Sleeve	5669288
Collar No. 1	5669282
Collar No. 2	5669283
Seal	5669280

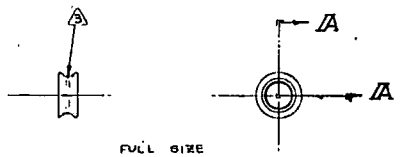
THE PART SHOWN HEREIN IS A PROPRIETARY PRODUCT OF PARKER AIRCRAFT CO. UNLESS NOTED AS CUSTOMER DESIGNED. PARKER RESERVES ALL PATENT AND PROPRIETARY RIGHTS TO THE INFORMATION AND DESIGN DISCLOSED HEREIN.

REVISIONS				
E.C.O. NO.	SYM	DESCRIPTION	DATE	APPROVAL
S&C 1924	-	RELEASED	9/6/66	
101	A	ADDED: A, .031 DIA HOLES; A_2 30°, A_3 DIM .004; A_1 ⚠4 NOTE; REVISED: A_2 ⚠4 WAS "INCO"; A_4 CLASS "B" WAS CL "A"; A_5 REMOVED 12/N	9/26/66	



HALF SECTION A-A
SCALE ~ 10X

NOTE:- LH LEG DETAIL SHOWS MACHINED DETAIL WHICH IS TYPICAL FOR BOTH SIDES. RH LEG DETAIL SHOWS FORMED & REMACHINED DETAIL TO BE PERFORMED ON BOTH SIDES



FULL SIZE

⚠5 ROCKETDYNE SPEC. RB-0170-038 (A4)
⚠4 PAR. 5.4.2 OF MIL-STD-171 (PASSIVATE)
⚠3 ELECTRO-CHEM ETCH P/N HERE (A1)
⚠2 AGE HARDEN @ 1350°F FOR 10 HRS, FURNACE COOL TO 1200°F FOR A TOTAL TIME OF 18-20 HRS.
⚠1 TRACEABILITY REQ'D PER BPS 5-19 CLASS B (A4)

NOTES (UNLESS OTHERWISE SPECIFIED)

ITEM NO.	DWG SIZE	QTY REQD	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL	MATERIAL SPECIFICATION	HEAT TREAT	FINISH	FINISH SPECIFICATION
(A3)				BAR	INCONEL 718	⚠5 ⚠1	⚠3 ⚠2	PASSIVATE	⚠4 ⚠1

LIST OF MATERIAL

NEXT ASSY	USED ON

APPLICATION

WELDED JOINT SYMBOLS PER MIL-STD-22
DIMENSIONAL SYMBOLS PER MIL-STD-8
— FLATNESS & STRAIGHTNESS
∠ ANGULARITY
⊥ PERPENDICULARITY
∥ PARALLELISM
⊙ CONCENTRICITY
⊕ TRUE POSITION
○ ROUNDNESS
⌯ SYMMETRY
Ⓜ DIMS MAXIMUM MATERIAL CONDITION
Ⓢ DIMS REGARDLESS OF FEATURE SIZE

UNLESS OTHERWISE SPECIFIED
DO NOT SCALE DRAWING
DIMENSIONS ARE IN INCHES
TOLERANCES
FRACTIONS ±1/64 DECIMALS .XXX ±.005 .XX ±.010 ANGLES (DEG) ±1/2°
TOLERANCES OF HOLES SPECIFIED TOO TIGHT PER MIL-STD-16
MUST CONFORM TO FS 1—1 MACHINED SURFACE 125/ PER MIL-STD-10 V
CLASSIFICATION OF CHARACTERISTICS PER BPS-5126 & MIL-STD-100
REF S124 - G.E.

SIGNATURES		DATE
DR BY	S.D. BURTON	8-4-66
DESCH BY		
CHK BY		
PROJ ENG BY	C.F. Hutton	8-8-66
APPVD BY		

Parker Aircraft Co. — LOS ANGELES, CALIFORNIA — DIVISION OF PARKER-HANNIFIN CORP

TITLE: COLLAR NO 1-X-FITTING, SIZE 8, 1,000 PSI, 700°F, (EDO)

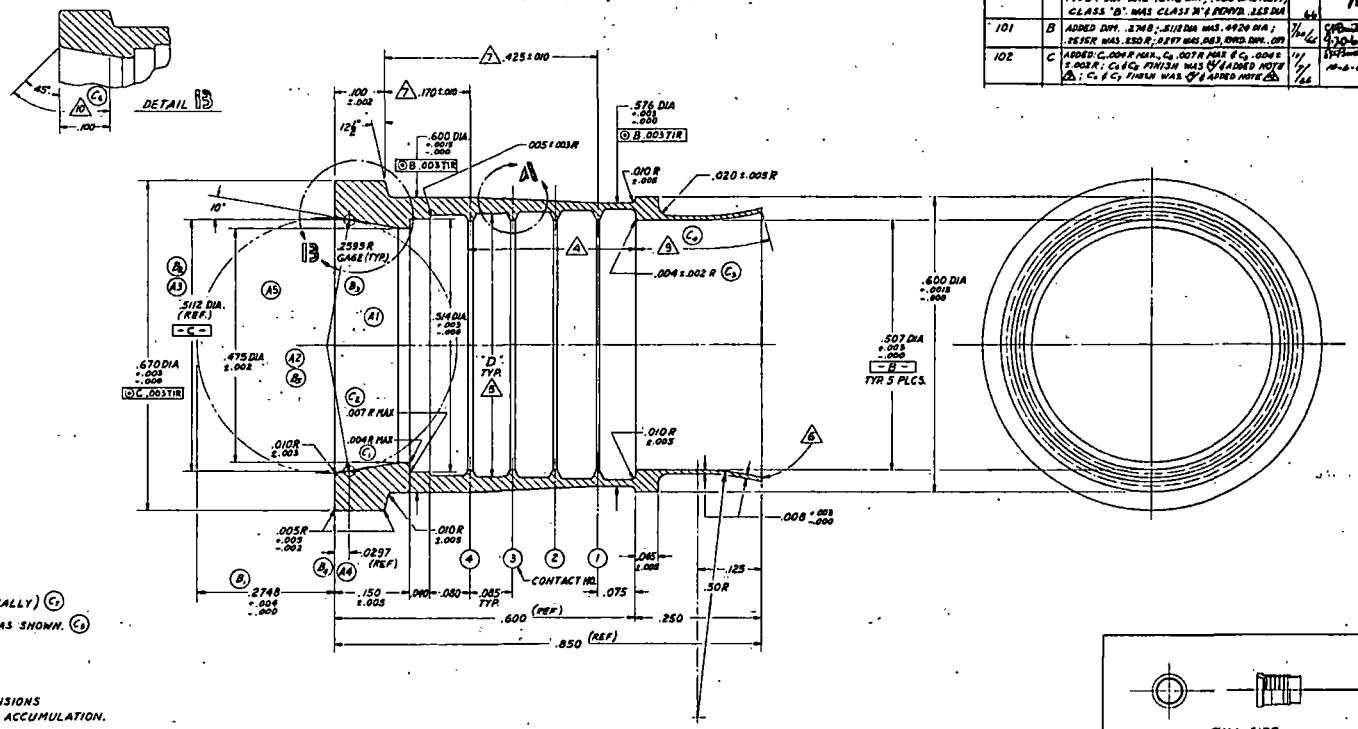
SIZE	CODE IDENT NO.	DWG NO.
D	92003	5669282

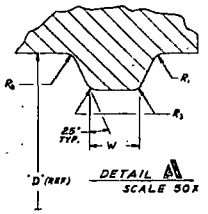
SCALE Noted | UNIT WT Actual Lbs .045 LBS | SHEET OF

5669282

THE PART SHOWN HEREIN IS A PROPRIETARY PRODUCT OF PARKER AIRCRAFT CO. UNLESS NOTED AS CUSTOMER DESIGNED. PARKER RESERVES ALL PATENT AND PROPRIETARY RIGHTS TO THE INFORMATION AND DESIGN DISCLOSED HEREIN.

REVISIONS				
E.C.O. NO.	SYM	DESCRIPTION	DATE	APPROVAL
566-1814	NC	RELEASE FOR EDO	9-10-44	
564-2111	A	.250R WAS .125R; .059 WAS .008; .4924 DIA WAS .5118 DIA; .083 WAS .0297 CLASS "B" WAS CLASS "A" & ROUND .165 DIA	9-1-44	
101	B	ADDED DIM. .2748; .5118 DIA WAS .4924 DIA; .2515R WAS .250R; .0297 WAS .083, RND. DIM. .09	9/14/44	
102	C	ADDED C, .004R MAX., C_6 .007R MAX & C_5 .004 ± .002R; C_4 & C_6 FINISH WAS $\sqrt{}$ & ADDED NOTE 4; C_1 & C_7 FINISH WAS $\sqrt{}$ & ADDED NOTE 4	11/1/44	10-6-44





Contact No	D +.003 -.006	R_1	R_2	R_3	W ±.002
1	.950	.006		.002	.005
2	.545	.005	.005	.002	.007
3	.540	.004	.004	.002	.010
4	.535	.004	.004	.002	.010
	.530		.004		

± .003
± .002
± .001
± .0005

(16) √c (LAY APPROXIMATELY CONCENTRICALLY) (C_7)

(20) √ AROUND INNER SURFACE OF ENTRY AS SHOWN. (C_6)

(8) ROCKETDYNE SPEC. RBO 170-138.

(7) THESE APPARENTLY REDUNDANT DIMENSIONS ARE FOR PREVENTION OF TOLERANCE ACCUMULATION.

(6) BREAK SHARP EDGES APPROX. .005R.

(5) ⊙ B .003 TIR

(4) (32) √ ON CONTACT FACES AS SHOWN.

(3) PAR. 5.4.2. OF MIL-STD-171 (PASSIVATE).

(2) AGE HARDEN @ 1350°F FOR 10 HRS., FURNACE COOL TO 1200°F, HOLD @ 1200°F FOR A TOTAL TIME OF 18-20 HRS.

(1) TRACEABILITY REQ'D PER ESS-19 CLASS "B". (A6)

NOTES: (UNLESS OTHERWISE SPECIFIED)

FULL SIZE

ITEM NO.	DWG SIZE	QTY REQD	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL	MATERIAL SPECIFICATION	HEAT TREAT	FINISH	FINISH SPECIFICATION
				BAR	INCONEL 718	(5) (1)	(2) (1)	PASSIVATE	(3)

LIST OF MATERIAL

WELDED JOINT SYMBOLS PER MIL-STD-22

DIMENSIONAL SYMBOLS PER MIL-STD-8
— FLATNESS & STRAIGHTNESS
∠ ANGULARITY
⊥ PERPENDICULARITY
∥ PARALLELISM
○ CONCENTRICITY
⊕ TRUE POSITION
○ ROUNDNESS
⌯ SYMMETRY
Ⓜ (MMC) MAXIMUM MATERIAL CONDITION
Ⓢ (RFS) REGARDLESS OF FEATURE SIZE

UNLESS OTHERWISE SPECIFIED
DO NOT SCALE DRAWING
DIMENSIONS ARE IN INCHES
TOLERANCES
FRACTIONS ± 1/32 | DEC ± .03 | DEG ± 1/2°
TOLERANCES OF HOLES SPECIFIED "DRILL" PER ANSI B 94.11
WORK CONFORMS TO ES 1-1 MACHINED SURFACE 125/ PER MIL-STD-10
CLASSIFICATION OF CHARACTERISTICS PER SPI-0256 & MIL-STD-105
REF 9124-GE/NASA

SIGNATURES		DATE
DR	AS RECEIVED	8-9-44
DESGN BY		
CHK BY	[signature]	8-10-44
PROJ ENG	[signature]	8-14-44
CHG BY		
APPD BY		

Parker Aircraft Co. LOS ANGELES, CALIFORNIA DIVISION OF PARKER-HANNIFIN CORP.

TITLE: SLEEVE #1 - X-FITTING, SIZE 8, 1000 PSI, 700°F, E.D.O.

SIZE	CODE IDENT NO.	DWG NO.
D	92003	5669288

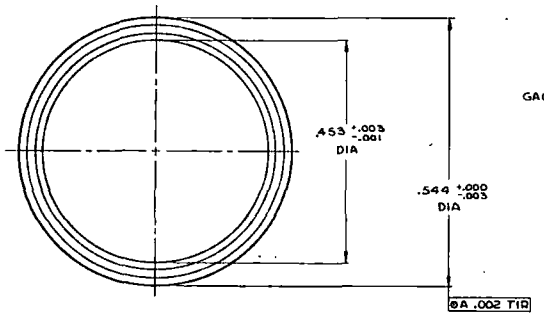
SCALE FULL | TOP POSITION | UNIT WT .016 LBS | SHEET 1 OF 1

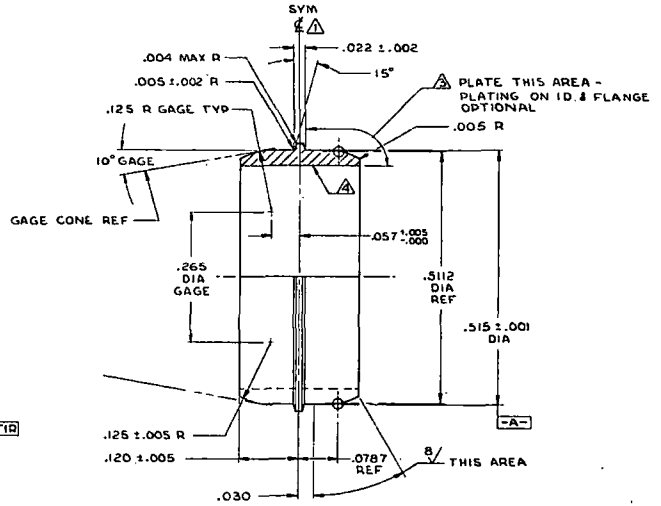
5669288

NEXT ASSY	USED ON
APPLICATION	

THE PART SHOWN HEREIN IS A PROPRIETARY PRODUCT OF PARKER AIRCRAFT CO. UNLESS NOTED AS CUSTOMER DESIGNED. PARKER RESERVES ALL PATENT AND PROPRIETARY RIGHTS TO THE INFORMATION AND DESIGN DISCLOSED HEREIN.

REVISIONS			
E.C.O. NO.	SYM	DESCRIPTION	DATE / APPROVAL
566-1816	-	RELEASED FOR EDO	4-14-66
566-2112	A	CLASS 'B' WAS CLASS 'A'	7-15-66





ACTUAL SIZE

5669280

1. ROCKETDYNE SPEC. R50 170-038
2. ALL DIMENSIONS TO BE MET BEFORE PLATING
3. ELECTROCHEM ETCH P.N. & SER NO. HERE
4. GOLD PLATE PER MIL-G-45204, TYPE II, CLASS 5 NOTED AREA
5. AGE HARDEN @ 1350°F FOR 10 HRS, FURNACE COOL TO 1200°F, HOLD @ 1200° FOR A TOTAL TIME OF 18-20 HRS
6. TRACEABILITY PER E&S-19, CLASS "B" (A)

NOTES (UNLESS OTHERWISE SPECIFIED)

ITEM NO.	DWG SIZE	QTY REQD	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL	MATERIAL SPECIFICATION	HEAT TREAT	FINISH	FINISH SPECIFICATION
-	-	-	-	-	INCONEL 718	4	1 1 2	3	3

LIST OF MATERIAL

NEXT ASSY	USED ON
APPLICATION	

WELDED JOINT SYMBOLS PER MIL-STD-22

DIMENSIONAL SYMBOLS PER MIL-STD-8

- FLATNESS & STRAIGHTNESS
- ANGULARITY
- PERPENDICULARITY
- PARALLELISM
- CONCENTRICITY
- TRUE POSITION
- ROUNDNESS
- SYMMETRY
- (M) DMIC MAXIMUM MATERIAL CONDITION
- (P) (RFS) REGARDLESS OF FEATURE SIZE

UNLESS OTHERWISE SPECIFIED
DO NOT SCALE DRAWING
DIMENSIONS ARE IN INCHES
TOLERANCES
FRACTIONS DEC ± .01 ANGLES ± 0°30'
.XXX ± .005 .XXX ± .010
± 1/32 TOLERANCES OF HOLES SPECIFIED "DRILL" PER ANSI B18.7
MUST CONFORM TO 125 MACHINED SURFACE 125/ PER MIL-STD-10
CLASSIFICATION OF CHARACTERISTICS
CD PER SPI-4234 & MIL-STD-105
REF S124-GE/NASA

SIGNATURES		DATE
DR BY	KISHPAUGH	7-15-66
DSGN BY		
CHK BY		7-9-66
PROJ ENG		7-9-66
APVD BY		

Parker Aircraft Co. LOS ANGELES, CALIFORNIA DIVISION OF PARKER HANNIFIN CORP

TITLE: SEAL NO. 1, X-FITTING, SIZE 8, 1000 PSI, 700°F (EDO)

SIZE	CODE IDENT NO.	DWG NO.
D	92003	5669280

SCALE 1/2 UNIT WT ACTUAL .005 LBS SHEET 1 OF 1

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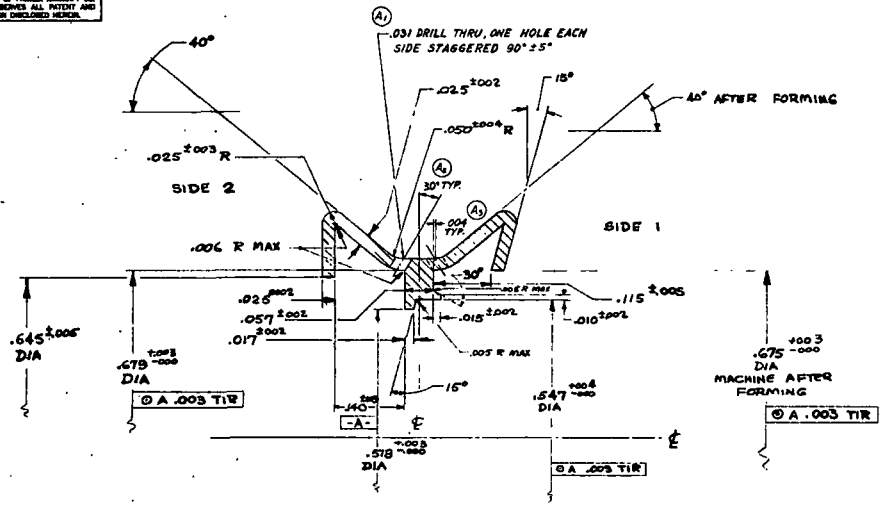
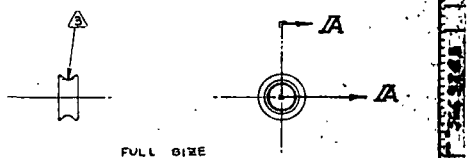
REVISIONS				
E.C.O. NO.	SYM	DESCRIPTION	DATE	APPROVED
566-1924	-	RELEASED	8/4/66	
101	A	ADDED: A, .031 DIA. HOLES; A, 38°; A, BSM.004; A, NOTE; REVISED: A, MAS "INCS"; A, CLASS "B" WAS CL "A"; A, RELEASED: 8/5/66	8/5/66	



HALF SECTION A-A
SCALE ~ 10X

NOTE:- LH LEG DETAIL SHOWS MACHINED DETAIL WHICH IS TYPICAL FOR BOTH SIDES. RH LEG DETAIL SHOWS FORMED & REMACHINED DETAIL TO BE PERFORMED ON BOTH SIDES



FULL SIZE

(A6)

ITEM NO.	DWG SIZE	QTY REQD	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL	MATERIAL SPECIFICATION	HEAT TREAT	FINISH	FINISH SPECIFICATION
				BAR	INCONEL 718	(3) (1)	(1) (2)		(4) (1)

LIST OF MATERIAL

(A1) ROCKETDYNE SPEC. RB-0170-038 (A6)
(A2) PAR. 5.4.2 OF MIL-STD-171 (PASSIVATE)
(A3) ELECTRO-CHEM ETCH PER HERE (A7)
(A4) AGE HARDEN @ 1350°F FOR 10 HRS, FURNACE COOL TO 1200°F FOR A TOTAL TIME OF 18-20 HRS.
(A5) MACHINABILITY REQ'D PER MS 5619 CLASS B (A6)

SIGNATURES	DATE
DR S.D. Buetow	8-4-66
DES	
ENG	
MFG	
QUAL	
ENG APPR.	8-4-66
CHKD BY	

Parker Aircraft Co. — LOS ANGELES, CALIFORNIA — DIVISION OF PARKER-HANNIFIN CORP.

TITLE: COLLAR NO 2-X-FITTING, SIZE 8, 1,000 PSI, 700°F, (EDO)

SIZE	CODE IDENT NO.	DWG NO.
D	92003	5669283

SCALE Keyed | UNIT WT | FINISH | LBS | SHEET OF

NEXT ASSY	USED ON
APPLICATION	

S124 - G.B.

APPENDIX III

Appendix III

FOUR-INCH, 1000-PSI CONNECTOR DRAWINGS

The parts shown in these drawings are intended for use with condition B tubing, with 0.083-inch wall thickness. The total length is rather long, being slightly greater than 13 inches. Feasibility of collar swaging has not been demonstrated.

If collar feasibility were demonstrated, the overall connector length would still have to be reduced. Length reduction would be accomplished by using a sleeve designed for a welded connection with condition A tubing. Design considerations indicate that such a sleeve would look like that shown in Parker drawing No. 5659323 but it would be truncated at the contact ring marked (8). The sleeve would have a close fitting socket to match the tube's outside diameter. The sleeve would taper more sharply than is shown in the drawing (5659323). Where the sleeve is truncated the sleeve thickness should equal the tube thickness. Welding would be full penetration through the sleeve and the tube, and would be in two axial locations.

Part	Parker Aircraft Company Drawing No.
Sleeve	5659323
Collar	5659324
Seal	5659322

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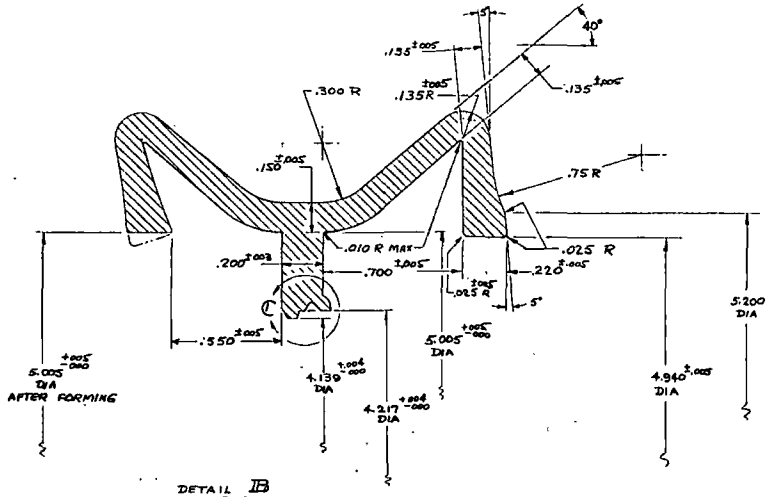
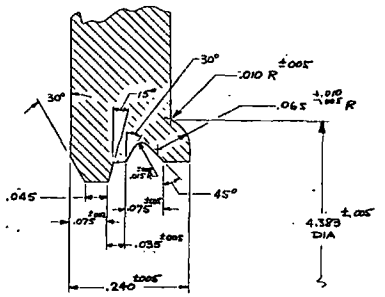
REVISIONS				
E.C.O. NO.	SYM	DESCRIPTION	DATE	APPROVAL
56F-2043	-	RELEASE FOR EDO	11/7/65	DH

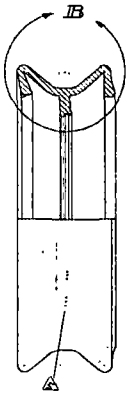


DETAIL B
SCALE - 4X

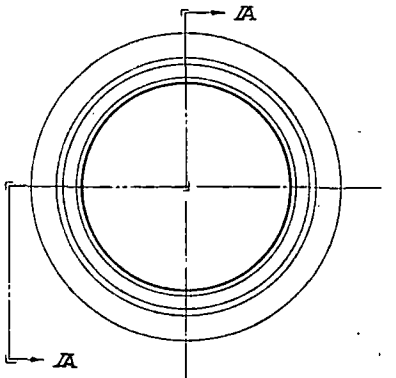
NOTE: RH SIDE OF SECTION SHOWS MACHINING DETAIL WHICH IS TYPICAL FOR BOTH SIDES. LH SIDE OF SECTION SHOWS FORMING & TRIMMING DETAILS WHICH ARE TO BE PERFORMED ON BOTH SIDES AFTER MACHINING.



DETAIL C
SCALE - 10X



SECT'N - VIEW A-A



5659324

1. ⚠ ELECTROETCH P/N & S/N HERE
2. ⚠ TRACEABILITY REQD PER 655-19 CLASS A
3. ⚠ MIL-P-16232, TYPE 2, CLASS 2
4. MAGNETIC PARTICLE INSPECT PER MIL-I-6868
5. ⚠ HEAT TREAT TO R_c 37-40 PER MIL-H-6875 & STRESS RELIEVE BEFORE FINAL MACHINING.

NOTES (UNLESS OTHERWISE SPECIFIED)

ITEM NO	DWG SIZE	QTY. REQD	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL	MATERIAL SPECIFICATION	HEAT TREAT	FINISH	FINISH SPECIFICATION
			BAR		4340	MIL-S-5000	⚠	PREPARE	⚠
						ALT: AMS 6415	⚠		

LIST OF MATERIAL

WELDED JOINT SYMBOLS PER MIL-STD-22
DIMENSIONAL SYMBOLS PER MIL-STD-8
— FLATNESS & STRAIGHTNESS
∠ ANGULARITY
⊥ PERPENDICULARITY
∥ PARALLELISM
◎ CONCENTRICITY
⊕ TRUE POSITION
○ ROUNDNESS
⌯ SYMMETRY
Ⓜ INMCI MAXIMUM MATERIAL CONDITION
Ⓢ (DIM) REGARDLESS OF FEATURE SIZE

UNLESS OTHERWISE SPECIFIED
DO NOT SCALE DRAWING
DIMENSIONS ARE IN INCHES
TOLERANCES
FRACTIONS DEC ± ANGLES ±
.XX ± .03 .XXX ± .010 ± 0°30'
TOLERANCES OF HOLES SPECIFIED "DRILL" PER ANSI B94.11M
MUST CONFORM TO TEST — 1
MACHINED SURFACE 125 PER MIL-STD-15 ▽
CLASSIFICATION OF CHARACTERISTICS PER BPR 4220-8 & MIL-STD-130
CD
REF 124 6.6

SIGNATURES		DATE
DR BY	B.D. BUETOW	9-24-65
DESIGN BY		
CHK BY	D. Johnson	11-7-65
PROJ ENG	G. Paxton	11/9/65
APPD BY		

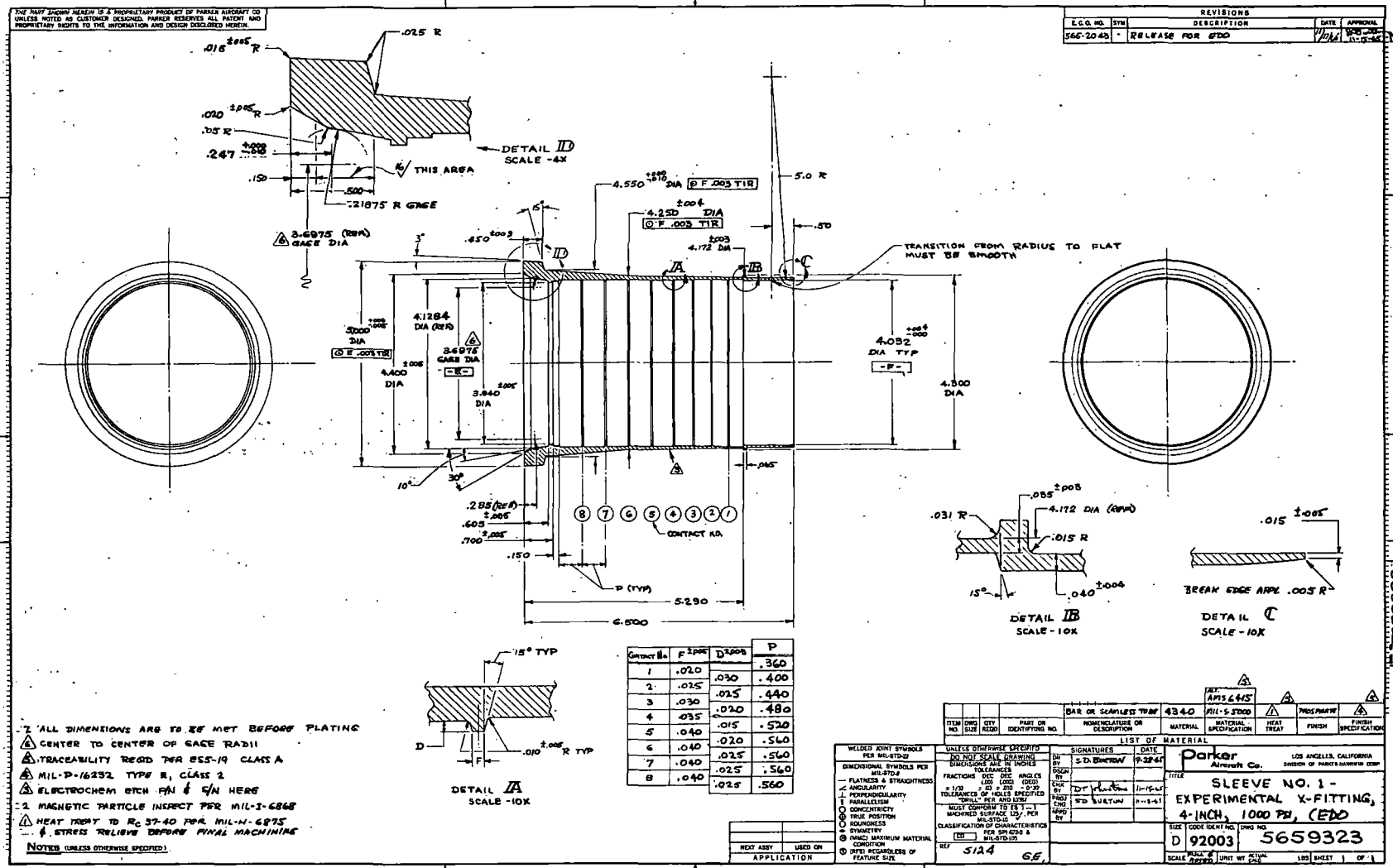
Parker Aircraft Co. — LOS ANGELES, CALIFORNIA — DIVISION OF PARKER-HANNIFIN CORP

TITLE: SWAGE COLLAR NO. 1 - EXPERIMENTAL X-FITTING, 4-INCH, 1000 PSI, (EDO)

SIZE	CODE IDENT NO	DWG NO
D	92003	5659324

SCALE	FSCM & NOMEN	UNIT WT NET/GR. LBS	SHEET 1 OF 1

NEXT ASSY	USED ON
APPLICATION	



Contact No.	F ±.005	D ±.005	P
1	.020	.030	.360
2	.025	.025	.400
3	.030	.020	.440
4	.035	.015	.480
5	.040	.020	.520
6	.040	.025	.540
7	.040	.025	.560
8	.040	.025	.560

1. ALL DIMENSIONS ARE TO BE MET BEFORE PLATING
2. CENTER TO CENTER OF GAGE RADII
3. TRACEABILITY REQD PER ESS-19 CLASS A
4. MIL-P-16232 TYPE II, CLASS 2
5. ELECTROCHEM ETCH P/N & S/N HERE
6. MAGNETIC PARTICLE INSPECT PER MIL-I-6868
7. HEAT TREAT TO R_C 37-40 PER MIL-H-6875 & STRESS RELIEVE BEFORE FINAL MACHINING

NOTES (UNLESS OTHERWISE SPECIFIED)

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REVISIONS				
E.C.O. NO.	SYM	DESCRIPTION	DATE	APPROVAL
566-2045	*	RELEASE FOR EDO	11/16	

ITEM NO.	DWG SIZE	QTY REQD	PART OR IDENTIFYING NO.	BAR OR SEAMLESS TUBE NOMENCLATURE OR DESCRIPTION	4340 MATERIAL	AMS 6415 MIL-S-5000 MATERIAL SPECIFICATION	HEAT TREAT	PASSIVATE FINISH	FINISH SPECIFICATION
				LIST OF MATERIAL					

WELDED JOINT SYMBOLS PER MIL-STD-22

DIMENSIONAL SYMBOLS PER MIL-STD-8

- FLATNESS & STRAIGHTNESS
- ANGULARITY
- PERPENDICULARITY
- PARALLELISM
- CONCENTRICITY
- TRUE POSITION
- ROUNDNESS
- SYMMETRY
- (MMC) MAXIMUM MATERIAL CONDITION
- (RFS) REGARDLESS OF FEATURE SIZE

UNLESS OTHERWISE SPECIFIED
DO NOT SCALE DRAWING
DIMENSIONS ARE IN INCHES
TOLERANCES
FRACTIONS ±1/32 DEC .XX ±.010 DEC .XXX ±.005 ANGLES 1.00 (DEG) ± 0°30'
TOLERANCES OF HOLES SPECIFIED "DRILL" PER ANSI B 94.11 (M82)
MUST CONFORM TO ISO — MACHINED SURFACE 125/; PER MIL-STD-16
CLASSIFICATION OF CHARACTERISTICS PER SPI 6720 & MIL-STD-105
CH
REF 5124 66

SIGNATURES		DATE
DR BY	S.D. EMERSON	9-28-66
DESGN BY		
CHK BY	DT Hamilton	11-15-66
PROJ ENG	ED SULTON	11-5-67
APPD BY		

Parker Aircraft Co. LOS ANGELES, CALIFORNIA DIVISION OF PARKER-HANNIFIN CORP

TITLE: SLEEVE NO. 1 - EXPERIMENTAL Y-FITTING, 4-INCH, 1000 PSI, (EDO)

SIZE	CODE IDENT NO.	DWG NO.
D	92003	5659323

SCALE FULL & ENLARGED | UNIT WT ACTUAL CALC | LBS | SHEET 1 OF 1

NEXT ASSY	USED ON
APPLICATION	

5659323

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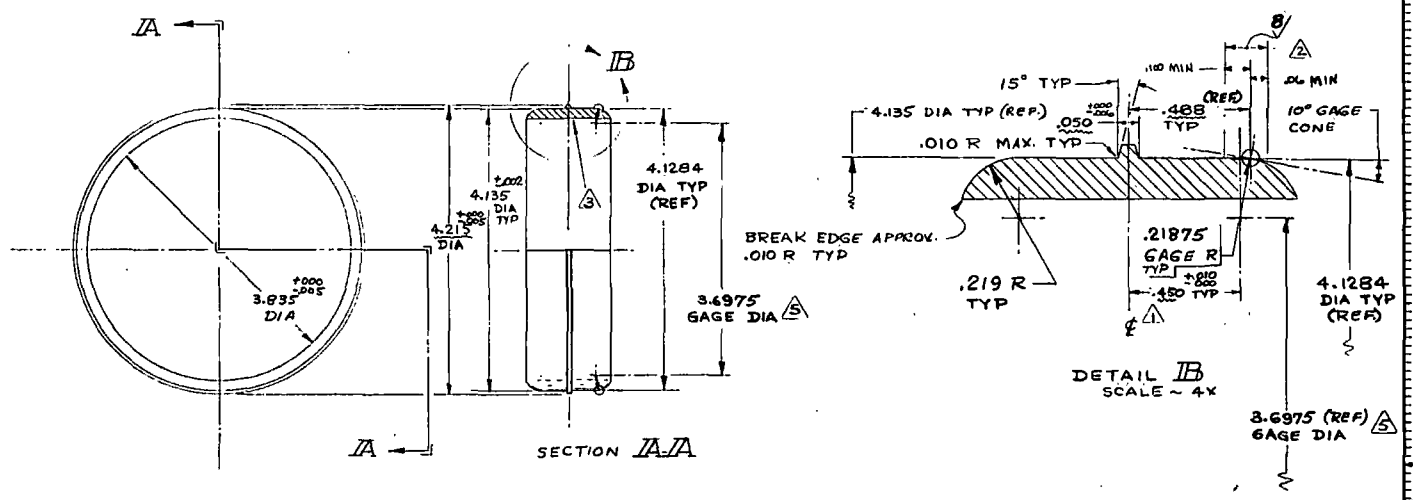
REVISIONS				
E.C.O. NO.	SYM	DESCRIPTION	DATE	APPROVAL
565-2043	-	RELEASED FOR E.D.O	11/11/65	11-15-65



8 MAGNETIC PARTICLE INSPECT PER MIL-I-6868

4 HEAT TREAT PER MIL-H-6875 & STRESS RELIEVE BEFORE FINAL MACHINING

6. ALL DIMENSIONS TO BE MET BEFORE PLATING

5 CENTER TO CENTER OF GAGE RADII

4 TRACEABILITY REQ'D PER ES 5-19 CLASS A

3 ELECTROETCH P/N & S/N HERE

2 MIL-G-45204 TYPE II, CLASS 5 NOTED AREA

1 ℄ IS DEFINED AS THE CENTER OF THE PROJECTING INDEX FLANGE AS LOCATED FROM THE 15° FACES

NOTES (UNLESS OTHERWISE SPECIFIED)

NEXT ASSY	USED ON
APPLICATION	

ITEM NO.	DWG SIZE	QTY REQD	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL	MATERIAL SPECIFICATION	HEAT TREAT	FINISH	FINISH SPECIFICATION
				SEAMLESS TUBE 3" Dia	4340 STL	AMS 6415 OR MIL-S-5000	Rc 37-40	GOLD PLATE	2

LIST OF MATERIAL

WELDED JOINT SYMBOLS PER MIL-STD-22

DIMENSIONAL SYMBOLS PER MIL-STD-8
- FLATNESS & STRAIGHTNESS
- ∠ ANGULARITY
- ⊥ PERPENDICULARITY
- ∥ PARALLELISM
- ⊙ CONCENTRICITY
- ⊕ TRUE POSITION
- ○ ROUNDNESS
- ⌯ SYMMETRY
- Ⓜ (MMC) MAXIMUM MATERIAL CONDITION
- Ⓢ (RFS) REGARDLESS OF FEATURE SIZE

UNLESS OTHERWISE SPECIFIED
DO NOT SCALE DRAWING
DIMENSIONS ARE IN INCHES
TOLERANCES
FRACTIONS ± 1/32 | DEC .XXX ± .010 | DEC .XX ± .03 | ANGLES (DEG) ± 0°30'
TOLERANCES OF HOLES SPECIFIED "DRILL" PER AND 10387
MUST CONFORM TO ES 1-1
MACHINED SURFACE 125√ PER MIL-STD-10
CLASSIFICATION OF CHARACTERISTICS PER SPI-622-5 & MIL-STD-105
CD
REF G.E. 5124

SIGNATURES		DATE
DR BY	S. D. BURTON	8-1865
DSGN BY		
CHK BY	D T Hughes	11-15-65
PROJ ENG	[illegible]	11-15-65
APPD BY		

Parker Aircraft Co. — LOS ANGELES, CALIFORNIA — DIVISION OF PARKER-HANNIFIN CORP.

TITLE: SEAL NO 1- EXPERIMENTAL X-FITTING, 4 INCH - 1000 PSI - E.D.O

SIZE	CODE IDENT NO.	DWG NO.
C	92003	5659322

SCALE FULL & NOTED | UNIT WT ACTUAL CALC | LBS | SHEET 1 OF 1

5659322